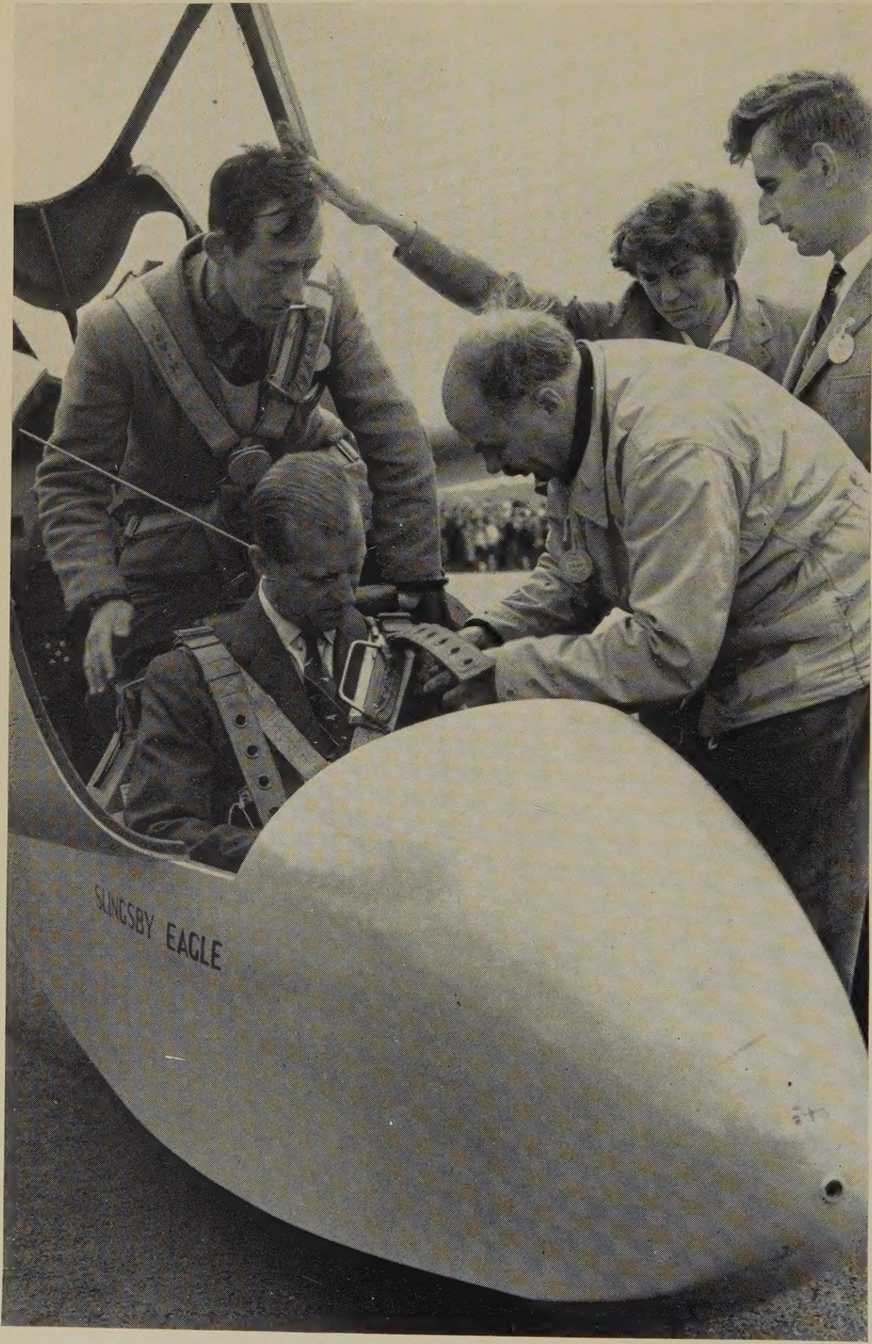
GLIDING

A Handbook on Soaring Flight



The author preparing for a flight with H.R.H. The Duke of Edinburgh in a T42b Eagle at Lasham, Hants

Photograph by Keystone Press Agency Ltd.

GLIDING

A Handbook on Soaring Flight

by

DEREK PIGGOTT

SECOND EDITION
WITH SIXTEEN PHOTOGRAPHS
AND 75 FIGURES

LONDON
ADAM & CHARLES BLACK

FIRST PUBLISHED 1958
REPRINTED 1959
SECOND EDITION 1967
BY A. AND C. BLACK LTD
4, 5 AND 6 SOHO SQUARE, LONDON, W.1

© 1967 DEREK PIGGOTT

Printed in Great Britain by Offset Lithography
by Billing & Sons Limited, Guildford and London

CONTENTS

SECTION I. LEARNING TO GLIDE

CHAPTER PAGE

1. First Flights in a Glider 2
2. Launching Procedure 10
3. The Effects of the Controls 15
4. Turning 19
5. The Take Off and the Launch 23
6. The Approach and Landing 28
7. Stalling and Spinning 32
8. Circuit Procedure 38
9. Cable Breaks 52
10. Rules of the Air 57

SECTION II. FURTHER TRAINING AND SOARING

11. More about Turning 60
12. Sideslipping 73
13. Better Launches 76
14. Landing out of Wind 81
15. More about Stalling and Spinning 85
16. Safe Flying in High Winds 95
17. Launching by Aerotow 106
18. Local Soaring and Efficient Cruising 118

SECTION III. EXPLORING THE SKIES

19. Thermals 130
20. Thermal Soaring 142
21. Hill Soaring 153
22. Wave Soaring 165
23. Landing in Strange Fields 170

24. THE INSTRUMENTS AND THEIR LIMITATIONS 187
25. INSTRUMENT FLYING 207
26. FLYING HIGH 223
27. FINDING YOUR WAY IN THE AIR 229
28. GOING FASTER AND FARTHER 239

APPENDIX 1. GLIDING AWARDS AND RECORDS 251
APPENDIX 2. THE GLIDING MOVEMENT IN GREAT BRITAIN 254
APPENDIX 3. OWNING YOUR OWN GLIDER 256
INDEX 261

LIST OF PLATES

1. The author preparing for a flight with H.R.H. The Duke of Edinburgh in a T42b Eagle at Lasham, Hants *Frontispiece*

FACING PAGE

2. Basic trainers:
    The Slingsby T49 Capstan two-seater
    The Slingsby Eagle two-seater
    Czechoslovakian Blanik, all metal two-seater
    The Slingsby T21b open two-seater
    The Slingsby Swallow, a single-seater for early solo flying 6
3. Two views of the Slingsby Dart 17R showing the retractable main wheel 73
4. The Polish Foka, winner of the World Gliding Championships in 1965 88
5. Aerobatics are fun! A Skylark 3 caught at the top of the loop 120
6. The Standard Austria, mainly of wood construction
    The American Sisu and Russian A15, all metal gliders
    The Phoebus, one of the first production machines of all glass-fibre construction, made in Germany 137
7. The German Ka6, probably the most widely used single-seater in the world, a popular club glider with an exceptional competition record 184
8. Competitors in the National Gliding Championships at Lasham preparing for take off 201

ACKNOWLEDGEMENTS

The author would like to thank Miss Peggy Lane for her generous help and advice, and Miss Sally Thompson, Mr. Charles E. Brown, Mr. F. N. Slingsby, The Keystone Press Agency and Sidney-Barton Ltd. for permission to reproduce photographs.

Section I

LEARNING TO GLIDE

This section gives you the information you will need before you make your first few solo flights and qualify for the "A" and "B" certificates. However, if you have not had the necessary flying experience, do not expect this, or any other book to teach you to fly. A book can only be a useful supplement to your gliding instructor and cannot replace him.

Although the handling of a glider is rather different from that of a modern light aircraft, any piloting experience will help to reduce the time spent learning to glide. Some gliding clubs encourage their members to start their training by having a few lessons on a powered aircraft and this is particularly worth while for beginners who have only a limited amount of spare time to devote to gliding.

Solo flight is the first step towards becoming a soaring pilot.

CHAPTER I

FIRST FLIGHTS IN A GLIDER

The layout of hill and airfield gliding sites—Fastening the safety harness—The cockpit layout and flying controls—First flights—Suitable clothing—Log books

DURING your first visit to a gliding site you may get the opportunity to fly in a glider as a passenger.

If you have never flown in an aeroplane or a glider, it is always possible to do this without committing yourself to the expense of a yearly membership of the club.

There is no doubt that you will be thrilled by the experience of gliding, but, before you begin to learn to glide you should consider carefully whether you are prepared to put up with the hard physical work and perseverance required. There will be times, particularly during your training, when you will have to wait most of the day for your turn of instruction.

Unlike learning to fly a powered aircraft, it is usually impractical to book glider flights in advance and it is, therefore, often necessary to spend at least half a day at the site when you go to fly.

Ideally, club members should either help to get the gliders and equipment to the launch point when flying begins, or they should help to put them away at the end of the day.

They should also do their fair share of pushing the gliders and helping in the many other tasks which need to be done to keep the gliding club operating.

The layout of a gliding site depends upon whether it is a hill site or a flat airfield. Where the site is close to a hill, a large field, or group of fields is used for take off and landing and the gliders are able to soar along the hill side when the wind is blowing in the right direction. A hill site is illustrated in Fig. 1. Launching is almost invariably by winch or bungee.

Today many of the most active clubs operate on flat sites or aerodromes and rely entirely upon thermals for soaring flights.

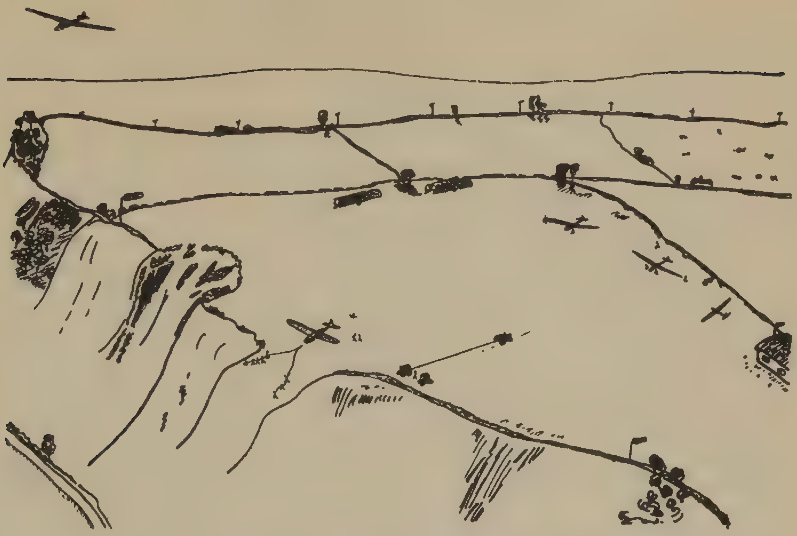


Fig. 1. A hill site using winch and bungee launching.

Fig. 2 shows a typical airfield gliding site with motor car towing in progress on the runway and with winch launching on the grass field on one side. Most clubs use one or other of these methods of launching their gliders.

The winches are positioned at the upwind end of the field in order to give the longest launching line more or less into wind.

In this case the winches have been sited slightly out of wind, and on the upwind side of the runway which is being used for motor car towing. This ensures that the tow car wire falls away from the winch cables so that the winch launching is not held up. The winch cable on the downwind side is used first to make sure that it falls well clear of the second cable. Both cables are wound up to the winch and clear of the runway after being used in order that they do not interfere with the motor car launching. The two winch cables are towed out to the launching point together by a tractor or a small truck.

The gliders normally aim to land about 150–200 yards from the boundary of the field. This allows them to approach at a safe height above any obstructions on the airfield boundary. The launches are, therefore, started from this position so that unnecessary effort is avoided in pushing the glider back for another launch. The field between the boundary and the landing area enables a safe landing to be made even if the pilot misjudges the approach and undershoots slightly.

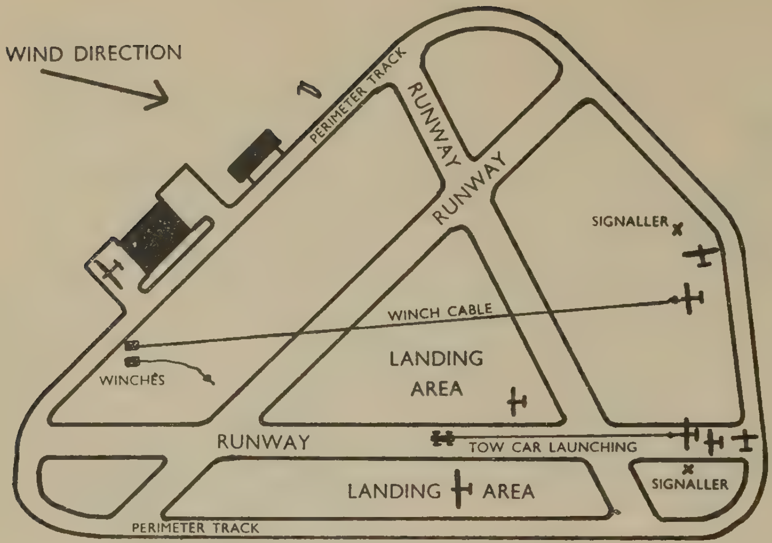


Fig. 2. The layout of an airfield gliding site.

The signallers are positioned to the side of the gliders being launched, where their signals can be clearly seen from the winch or tow car. The launching is usually supervised by an instructor assisted by club members.

Gliders which are not about to be launched are parked at right angles to the wind direction with tyres on the upwind wing tip.

A log of all flights is kept by one person at the take-off point in order to record details of each flight.

Even if you are visiting a gliding site for the first time you can help with the ground handling while you wait for a chance to fly.

You will be asked to sign an indemnity form before going up in a glider and, if you are under twenty-one the form must be countersigned by a parent or guardian. This indemnity absolves the club from liability for injury while you are on the ground or flying. Flying risks are almost insignificant for normal training and club flying.

There are greater risks on the ground from tow cars and winch cables and gliding is far less risky than playing football.

Your pilot will show you how to climb into the glider.

It is always quite safe to step onto the centre of the seat and then onto the floor or foot boards on either side of the control column. You may find that you need some padding behind you in order to reach the controls and rudder pedals easily. In this case you should remember to bring suitable cushions every time you come to glide so that you will always be sitting at the same height and position on instructional flights.

Your instructor will help you to fasten the safety harness when you are sitting in the cockpit. The purpose of the harness is to prevent the pilot from moving in his seat in bumpy conditions in flight and to prevent injury which might occur in a bad landing through the pilot moving forward and striking the instrument panel. An efficient harness must, therefore, hold the pilot round the waist and shoulders.

With the old "Sutton" type of harness, after getting into the cockpit it is best to lay out all four straps in position before attempting to fasten them. The top left strap has a movable peg which should be adjusted to a position just below the solar plexus. The other straps can then be fastened over this peg and finally locked with the triangular clip. The correct order for fastening them is: top left, bottom right, bottom left, top right and then the fastening clip.

The "Q" type harness is an improved version of the Sutton harness and is fitted with adjustable straps and a quick release box in place of the locking pin, etc. First check that the quick release box is set to "Fasten" and then insert the lower strap into the appropriate slot. The lower straps should then be tightened so that the box is as low as possible. The shoulder straps are then inserted and tightened as necessary.

The harness can be quickly released by turning the lever on the release box in either direction.

It is very important to adjust the harness until it is tight so that you are held firmly in position and feel as though you are really a part of the aircraft.

There is nothing more uncomfortable than having the harness too loose so that you move in the seat. Even if your straps feel too tight when they are first adjusted, after a few moments they will ease off as you settle into the seat.

The next thing to do is to look round the cockpit at the controls and instruments. The cockpit layout for a typical glider is shown in Fig. 3.

The flying controls consist of the control column and the rudder pedals.

The instruments generally include an airspeed indicator, altimeter, variometer, turn and slip indicator and a compass. These are unimportant on the first few flights.

The release knob for the launching cable is painted yellow and is generally on the left of the instrument panel.

There is also a lever for operating the airbrakes or spoilers and probably a small lever for adjusting the elevator trim tab.

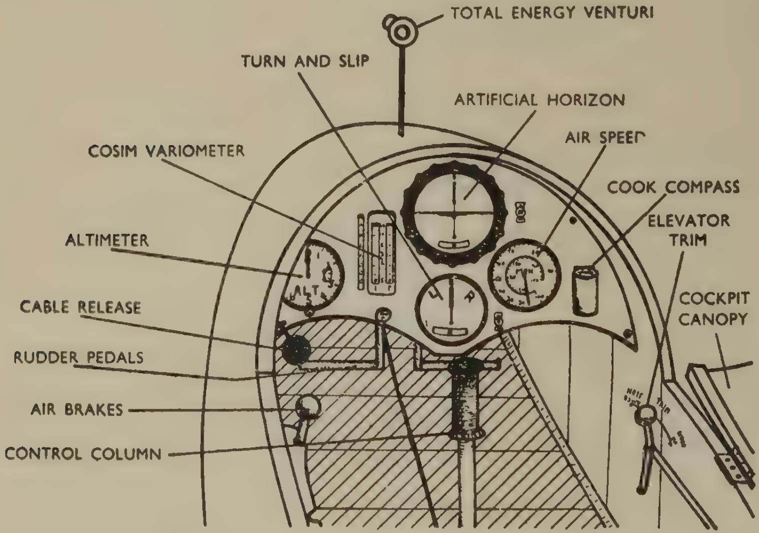


Fig. 3. The cockpit layout of a modern glider.

The most important lesson in the air experience flights is the art of relaxing in the air and becoming a part of the glider as it banks and turns. Banking in an aircraft is similar to leaning over on a bicycle. It is necessary to learn to lean over with the glider in a turn instead of trying to sit upright in relation to the ground.

It is also necessary to accustom yourself to looking at the ground. Strangely enough there is no real sensation of height such as you get from looking down from a tall building. You need not worry if you have a bad head for heights as flying will not affect you in the same way.

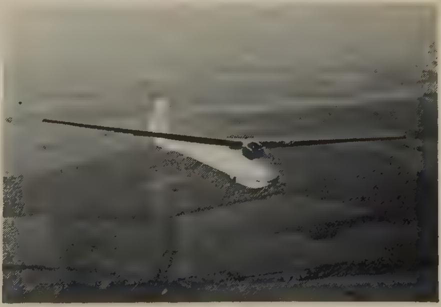
During these first flights, the instructor will not be making any violent manoeuvres or aerobatics. Most of the time will be spent getting to know the layout of the site and the local landmarks.

The Slingsby T49 Captstan two-seater

The Slingsby Eagle two-seater

The Czechoslovakian Blanik, an all-metal two-seater

The Slingsby T21b two-seater



The Slingsby Swallow, a single-seater for early solo flying

Photographs by Charles E. Brown

or hangar and by talking about flying when the weather is too bad to fly.

A small minority of people benefit from training over a long period since they take longer to acclimatize themselves to flying and to learn to relax.

CLOTHING

It is not necessary to buy expensive clothes specially for gliding. Any old clothes that you do not mind getting dirty would be suitable. However, most gliding sites are situated in exposed places and, even in the summer, warm clothing is needed for flying.

A hat or beret of a type which cannot be blown off by the airflow is advisable to prevent your hair getting into your eyes.

Some inexpensive sort of boiler suit or overall will help to keep the wind out and save your clothes from getting too dirty. The ideal flying suit for gliding is an ex-R.A.F. light-weight flying suit. This is shower proof and wind proof but is not too hot for strenuous work.

In winter, warm pullovers and gloves and waterproof boots or Wellingtons are necessary to keep reasonably warm and dry.

If all your flying is likely to be in open types of gliders, it is worthwhile buying a pair of goggles as a protection against rain or hail. The best type to buy are the ex-R.A.F. flying goggles which are obtainable at most Government surplus stores. They are splinter proof and have alternative tinted lenses for very bright days. Goggles for flying must allow a full range of vision sideways. Many types of motor cycle goggles act as blinkers and restrict the vision to a dangerous extent.

Since you are bound to get dirty sooner or later when you are gliding, do not make a habit of arriving in your best suit. This will infer that you are not willing to help with the work involved in keeping the aircraft flying.

LOG BOOKS

As soon as you start your glider flying you will need a log book in which to record your flights. An inexpensive glider pilot's log book can be obtained from the British Gliding Association or from your club.

An accurate record of all your gliding is essential so that, if you visit another club, you have documentary proof of your gliding experience and ability. Your log book should be signed by your chief flying instructor periodically, particularly if you are visiting a gliding club in another country and you hope to fly there.

As you gain experience your log book begins to have a considerable personal value when you look over the pages. Most pilots like to keep barograph charts, photographs and notes on flights of interest in their log books. It is well worthwhile spending an extra few minutes writing the entries in neatly rather than finishing up with a log book of which you are ashamed.

CHAPTER 2

LAUNCHING PROCEDURE

Attaching the cable—Launching procedure and signals

ATTACHING THE CABLE

MODERN British gliders are fitted with the Ottfur type of towing hook. The Ottfur release is normally operated by the pilot who pulls the yellow release knob in the cockpit to drop the cable. However, if the pilot fails to release the cable at the top of the launch, the cable will release itself automatically as soon as the pull of the cable becomes directly downwards or backwards. The automatic or override mechanism eliminates the risk of accident if the pilot cannot release the cable by the normal method.

It is important to test both methods before the first flight of the day in order to make quite sure that the release is functioning correctly.

The manual operation should be checked by releasing the cable while the cable is being pulled downwards and forwards by the person attaching it.

The automatic part of the release is tested by pulling the cable backwards towards the tail of the glider so that it releases itself.

After the first flight of the day the release need not be tested again between flights.

On some types of gliders two releases are provided. Motor car and winch launches are normally made with the cable attached to the rear release which is usually mounted somewhere below the pilot's seat. The front or nose hook should only be used for aerotow launches and towing on the ground. If the front hook is used for a winch or car launch, the climbing angle will be restricted and it will be difficult to reach a normal launching height. An aerotow launch may be more difficult to control if it is made on the rear hook because of the increased tendency for the glider to climb above the towing aircraft.

The cable should not be attached to the glider until the occupants are strapped in and are ready for the launch. Should the flight be postponed or delayed, the pilot should release the cable immediately so that at no time is the cable attached to the glider unless it is actually about to be launched.

The person attaching the cable is expected to carry out a quick check of the parachute, weak link, rope and rings to make sure that they are serviceable. Fig. 4 shows the arrangement of the parachute, etc, at the end of the cable.

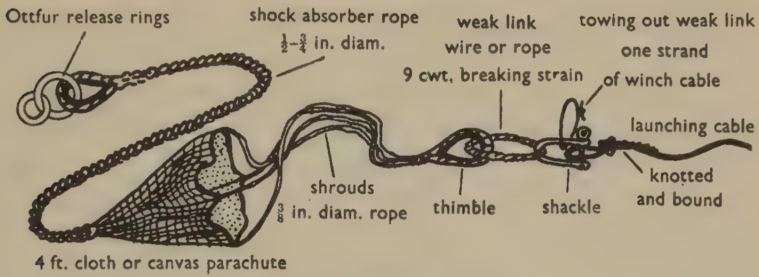


Fig. 4. The cable make-up.

The weak link is of vital importance for safe launching because the main cable will stand a much greater load than the wings of the glider. The weak link is normally designed to break with a load of nine hundredweight which is before there is any risk of overstressing the wings of the glider.

The release rings should be inspected before every flight to see that they are not elongated. The larger ring acts as a fatigue indicator and, being of greater diameter but made of the same material, it elongates first if the material fatigues. It is of vital importance to see that the smaller ring is round as otherwise it may jam in the release under load. The small ring should pass into the release easily and, after attaching the cable, the rings should be rattled to make sure that they are free to move. If the rings will not rattle, it is possible that they are either bent or oversized, and that they may prove difficult to release at the top of the launch.

An elongated or oversized ring is the *only* possible cause of the cable failing to release with the Ottfur type of release. On *no* account may home-made or non-standard rings such as links of chain be used for launching gliders.

After attaching the cable, it should be given a strong tug to make sure that it is secure.

LAUNCHING PROCEDURE AND SIGNALS

In the past there have been many dangerous incidents directly attributable to poor procedure leading up to the launch. Slack procedure may result in the glider being launched before the pilot is fully prepared or while onlookers are standing too near or even in front of the aircraft.

At one gliding site a pupil was actually launched off while waiting for the instructor to climb into the back seat of a two-seater. Fortunately he was almost ready for his first solo and had no difficulty in making a circuit and landing. This incident shows the need for the pilot to give clear orders for launching and for the signaller to insist on an order and to take no notice of vague hand signals from the pilot. Otherwise the pilot may find himself launched before he is ready if he happens to so much as scratch his face.

Whereas only the pilot should be able to initiate the launch, anyone can give the order to stop it. On hearing a shout of "Stop", the pilot must release the cable immediately. It is the duty of every person on a gliding site to stop the launch if there appears to them to be the slightest risk of an accident if the launch continues.

Launching signals and procedure are more or less standard so that wherever you glide in England similar signals are in use and there is no risk of confusion.

The launching signals are normally given by bats or flashing light signals. Obviously, for safe operation they must be clearly visible from the winch or tow car a mile or more across the airfield.

The signaller should repeat back the orders which he receives so that the pilot is certain that his orders have been correctly heard and that the signals are being given.

The signals used are, "Take up slack", "All out", and "Stop". (Fig. 5.)

The "Take up slack" signal gives the car or winch driver permission to select the gear for the launch and to take up the slack in the cable so that the glider will not receive a severe jerk when it is launched.

The "All out" signal means that the slack is out of the cable and gives the driver permission to go ahead with the launch and the "Stop" signal tells the driver to stop the launch immediately.

If light signals are being used, the "Dashes" and "Dots" must be long enough to allow the bulb to light up clearly for the "Dots" and for there to be a distinctive difference between the two signals. A definite difference in rhythm will also help to make the signals easier to read at a glance. The lamp is usually mounted on a stand so that it cannot be wrongly aimed while the signals are being given.

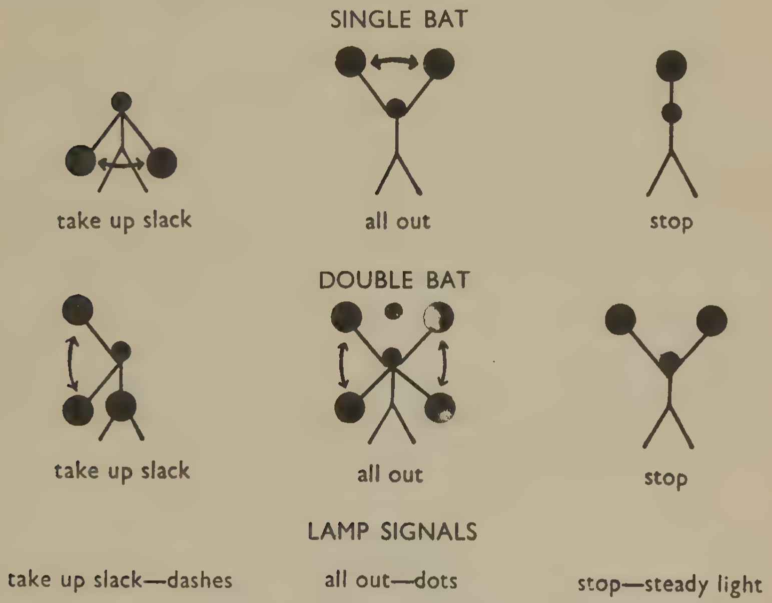


Fig. 5. Launching signals.

If it is necessary for the person holding the wing tip to give the launching signals at the same time, the single bat signals must be used. Signalling by rocking the wings is dangerous as there is no means of giving a "Stop" signal after the glider has begun the take off. A "Stop" signal would be vital if, for instance, the glider overran the cable so that the parachute became entangled with the skid.

The importance of an efficient method of signalling is shown by the example I have given of just one of the serious incidents which can easily occur through slipshod launching procedure. Obviously, whatever method of signals is used, it must be possible to give the "Stop" signal at any time during the launch.

Ideally, all launching signals should be acknowledged by another signaller at the winch so that the pilot and signaller can see that the winch is receiving the signals correctly. This can save the signaller calling for the launch and wondering whether his signals are being received. If the winch is temporarily out of action, the signaller there should give a "Stop" signal as this will save unnecessary signalling at the launch point. A "Ready" or "Take up slack" signal can then be given from the winch as soon as it is ready to launch again.

On some gliding sites, the winch may be out of sight of the launch point and an intermediate signaller is needed to relay the signals in the middle of the field. This signaller must always face the launch point with his back to the winch as he signals so that he will see a "Stop" signal immediately if one is given.

The use of a telephone and radio communication for signalling has been tried but it is neither cheap nor foolproof. With either of these methods, a failure of the system, or difficulty in hearing above the noise of the winch engine at full power, might result in the launch being continued despite a "Stop" signal. Radio communication between the pilot and the winch can help to obtain the ideal launching speeds, and this gives an improvement of up to 30 per cent in most conditions. However, it is expensive and too complicated for everyday use on the average gliding club site.

CHAPTER 3

THE EFFECTS OF THE CONTROLS

The primary and further effects of the controls—The correct flying attitude

If you do not understand the use of the individual controls, you are bound to find it impossible to fly a glider. It is, therefore, the first and probably the most important lesson for the beginner to learn.

There are three flying controls in a glider, the elevators, the ailerons and the rudder.

The elevators and ailerons are both operated by the control column (or stick) and the rudder by the rudder pedals.

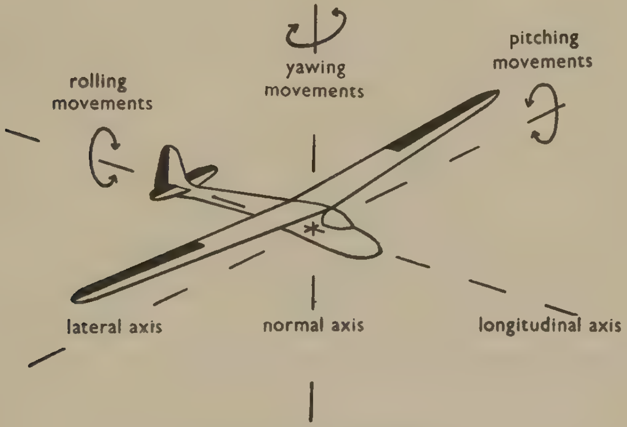


Fig. 6a. Axes of movement.

All of the controls are easy to move and require very little pressure to move them. The stick should be held with a light hold with the right hand and the feet should rest lightly on the rudder pedals.

The primary effect of each control is to move the aircraft about one particular axis. (See Fig. 6.)

The elevators control movement of pitch, nose up or down about the lateral axis.

The ailerons control rolling or banking movements about the longitudinal axis.

The rudder controls yawing movements about the normal axis.

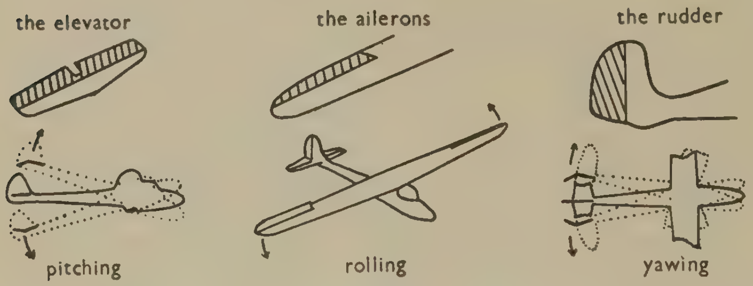


Fig. 6b. The effects of the controls.

It must be noted that the controls act about these same axes whatever attitude the aircraft may be in. For example, in normal flight a movement forward on the control column lowers the nose. The same movement in a turn produces a similar pitching movement about the same axis.

The easiest way to think of this is to do your safety harness up tightly so that you can really imagine yourself as a part of the glider or as having strapped your wings on. The controls will always react in the same way in relation to your position in the cockpit.

The elevators and ailerons are easy to master; to lean forward or put the nose down, move the stick forward, and to lean to the left or bank to the left, move the stick to the left.

The rudder movements are not instinctive but are quickly learnt by practice.

Applying left rudder by moving forward on the left foot swings or yaws the nose to the left; right rudder swings the nose to the right.

The effectiveness of these controls depends on the speed of the airflow over the controls and the amount they are moved. At low speeds larger movements are required to produce the same effects. At very low speeds (near stalling), the controls become very ineffective and do not always produce the normal effects.

A glider is flown by moving the controls as much as is necessary to obtain the attitude or manoeuvre required, without any reference to the exact position or movement of the control in the cockpit. If the glider is flying slowly or is being tipped by a gust, much larger movements on the controls will be necessary than in normal flight.

The speed of a glider is controlled by its fore and aft attitude. A nose down attitude results in a higher speed than normal cruising speed and each position for the nose gives a certain steady speed (unless the glider is stalled).

The best gliding speed can be maintained without the need to refer to the airspeed indicator by keeping the nose of the glider in the correct position in relation to the horizon. If the nose is held too high, the airspeed will be below normal flying speed and if the nose is too low, the speed will be excessive. Both these faults will result in a greater rate of descent than normal and therefore, for efficient gliding flight, the nose must be in the correct attitude.

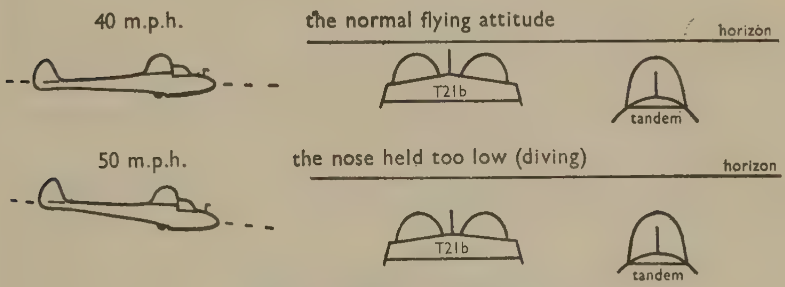


Fig. 7. Flying by attitude.

On one of your first flights the instructor will point out the position of the nose in relation to the horizon for normal cruising flight. The exact position for you will depend on your height in the cockpit but will be something like Fig. 7. It is vital for you to learn to recognize this attitude as early as possible.

If the air is smooth, the glider will tend to fly along in the correct attitude with very little help, because of its natural stability. Normally, however, small corrections have to be made to keep the nose in the correct attitude, and to keep the wings level when the glider is tipped by disturbances in the air.

You will have noticed from watching both gliders and powered aircraft that the wings are always banked during a turn. Unlike a ship, a turn in an aircraft is made almost entirely by applying bank. The rudder, although essential, plays only a minor part in the work of producing a turn.

If the glider is banked without rudder, it commences a side slip towards the lower wing and then turns in the direction of the bank and the nose falls below the horizon. This is sometimes known as the further effect of the aileron and is important because it is the basis of the normal turn. In an accurate turn, the application of a little rudder in the direction of the turn prevents the sideslipping and a slight backward pressure on the stick keeps the nose from dropping. Even the slightest amount of bank will cause a turn and, for this reason, if you find the glider turning you can assume that one wing is down slightly.

When the rudder is applied while the wings are held level, the nose swings to the side but the glider flies on in almost the same direction as before, skidding sideways through the air.

If the wings are not held level, the glider will begin to bank in the direction of the movement of the nose, and turn will develop with the nose being pulled down by the yawing of the rudder when the glider is banked. The drag of the glider flying sideways is very large, and this makes a turn by rudder alone extremely inefficient and a potentially dangerous manoeuvre.

In flight, the rudder should be used only to assist the aileron in turning the glider. When the glider is on the ground, it is steered by rudder while the wings are kept level with the ailerons.

Your instructor will almost certainly draw your attention to the sound of the airflow in flight at various speeds. As you become more experienced you will realize that hearing can play a vital part in gliding and that sound is more reliable than an airspeed indicator which can easily become damaged or iced up just when it is most needed.

CHAPTER 4

TURNING

How to turn the glider—Slip and skid and how to correct them

ALTHOUGH accurate turning is the basis of efficient thermal soaring, accuracy is by no means the most important thing to learn. It is true that careless handling can result in an accident, but failing to look around for other aircraft is far more dangerous to both yourself and your friends in other aircraft around you.

The view from a glider is often very much restricted by the wings and nose and you must remember that only a thorough constant look-out by every pilot will ensure that collisions are avoided.

It is essential to maintain a safe speed during the turn because of the slightly raised stalling speed.

The turn should be made in the following manner:

Look around both ways and particularly in the direction in which you are about to turn and make sure there are no other gliders near you.

Check that the position of the nose is correct before you apply bank in the direction of the turn, and a little rudder. Then hold the angle of bank constant throughout the turn by making a small "check" move with the aileron to prevent the bank from becoming too steep and then by making adjustments as necessary to maintain the bank steady. At the same time reduce the rudder so that only a very small amount remains in the direction of the turn.

To come out of a turn:

Take off the bank and assist by using a little rudder (as though going into a turn in the other direction).

Hold the wings level and centralize the rudder and settle down to the normal cruising attitude.

You will experience three minor problems learning to turn the glider: maintaining the bank; keeping the nose in a constant attitude; and co-ordinating the rudder correctly with the aileron movement.

The first two problems are overcome very quickly if you watch the position of the nose during the turn after having a thorough look around beforehand. Disturbances in the air will upset the angle of bank and attitude during the turn, and you will have to make corrections on the aileron and elevator to try to hold the turn constant. If you are trying to come out of the turn in a definite direction, as for instance on the final turn onto the approach into wind, start to bring the wings level about 20–30 deg before the desired direction. In this way, by the time the wings are level, the glider will be heading correctly.

Co-ordination of the aileron and rudder is mainly a matter of practice. At first you will find it necessary to think about the rudder movements but as you gain experience they will gradually become largely instinctive. It is necessary to use the rudder whenever the ailerons are moved and it is easiest, at first, to think of the rudder as assisting the aileron. For example, supposing the left wing drops in cruising flight, the wing must be raised by moving the control column to the right and at the same time using a little right rudder (right foot forward).

As the wings are levelled, both corrections can be taken off. Similarly, if the left wing drops on the launch, both controls must be used. Recovering from a turn to the left, where the left wing is down, the stick must be moved to the right and right rudder applied to help the glider out of the turn.

If no rudder is used, any small correction with the aileron will result in the glider yawing about and it will be very difficult to fly straight.

Co-ordination of aileron and rudder can be practised while sitting in a glider on the ground with the wing tip held off the ground, or in windy conditions with the wings balanced facing into wind. Practice of this sort enables you to get hands and feet working together in the right direction. However, practising balancing the wings without trying to co-ordinate with the rudder is a waste of time after you have made a few flights.

Accuracy in turning is not so important at first as using the right procedure.

If the glider has side-by-side seating, the effect of sitting to one side of the cockpit may cause an inexperienced pilot difficulties in maintaining the correct gliding attitude in turns. (Fig. 8.)

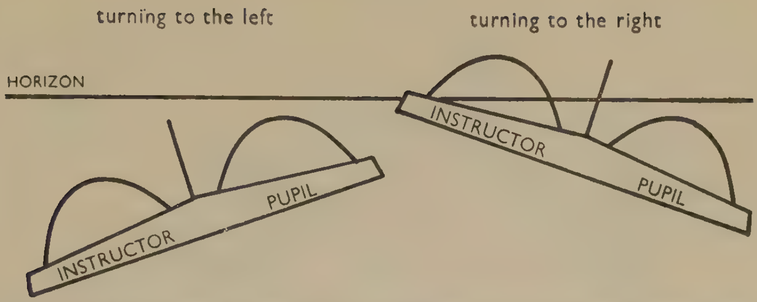


Fig. 8. View from pupil's seat of the T21b trainer showing the assymetric view in turns. Note that the top of the pupil's windscreen remains in a constant position in relation to the horizon but the pitot tube varies considerably.

Slip and skid in turns are caused by failing to co-ordinate the rudder and aileron movements correctly. It is easiest to think of the correction as being made with one control, the rudder. If you bank the glider to the left without using sufficient left rudder, the glider will sideslip during the turn towards the lower wing. This can be detected by the airflow striking your left cheek instead of the full face if the glider is an open cockpit one, by the deflection of a piece of string tied to the pitot head or by the indication of the slip indicator on the turn and slip indicator if one is fitted. (See Fig. 9.) The correction is to apply left rudder until the slip ceases. (Airflow on left cheek more left rudder.)

If too much left rudder had been applied in the turn to the left, the glider would skid round and the airflow would strike your right cheek. The correction, the draught is on your right cheek, therefore more right rudder or less left rudder will put this right.

These errors in turning have a serious effect on the rate of sink because of the tremendous increase in fuselage drag when the fuselage is forced through the air sideways by the misuse of the rudder.

The terms slip and skid become very confusing. It is easier just to consider the turn as inaccurate, or unbalanced, than to try to interpret the errors into terms of slip and skid.

During the entry and recovery from a turn, errors in co-ordination of the ailerons and rudder which cause momentary slipping and skidding, can be seen by looking ahead over the nose of the glider.

As the bank is applied, the glider should begin to turn immediately in the direction of the bank, the rate of turn increasing smoothly as the bank increases. Any hesitation or swing of the nose in the

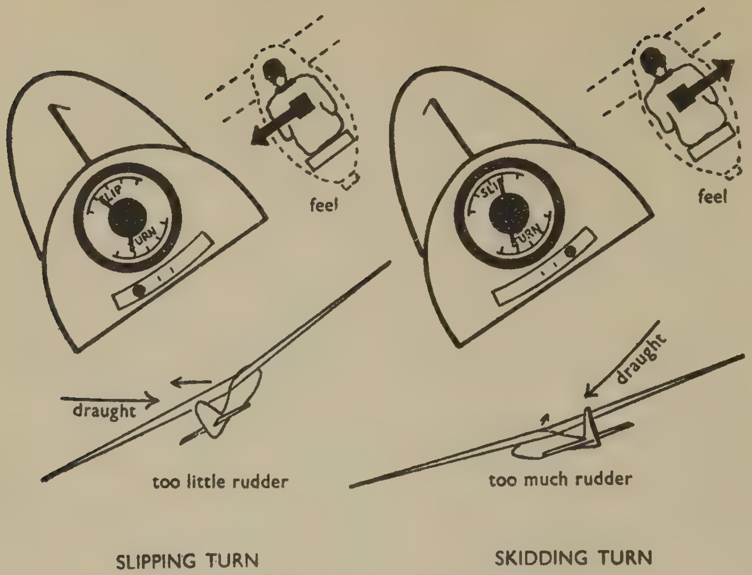


Fig. 9. Slipping and skidding in turns.

opposite direction indicates that insufficient rudder was applied at the commencement of the turn.

When the glider is coming out of or reversing the direction of the turn, it should gradually stop turning as the bank is reduced. Too much rudder will stop the turn before the wings are level, whereas too little rudder will allow the turn to continue for a few seconds after the wings are level.

These faults are usually only momentary and cannot be corrected once they have occurred. They must be prevented by good co-ordination as they spoil the entry and recovery of turns and make centring in thermals very difficult.

CHAPTER 5

THE TAKE OFF AND THE LAUNCH

Cockpit drills—Winch and motor car launches

With a winch or motor car tow, the launch is probably the easiest part of the flight, because the glider is very stable and will almost carry out the launch unassisted. Provided that the initial part of the launch to a height of about 150 feet is carried out correctly, there is no real danger of accident in the event of a cable break or winch failure. Should the cable break while you are learning to carry out the launch, the instructor can easily take over. Later you will receive plenty of instruction and practice in dealing with cable breaks.

Before each flight, a drill of vital actions is carried out to ensure that nothing vital is overlooked. It is best learnt by the mnemonic CB SIT CB.

C CONTROLS, check for full, free and correct movements.
B BALLAST, check the cockpit placard to see if ballast is required and the stowage points to ensure that the correct ballast is properly secured, or removed.
S STRAPS, check that all safety harnesses are done up.
I INSTRUMENTS, check for obvious errors, set the altimeter and test those electrical instruments needed for flight.
T TRIM, set the trimmer to neutral or as required.
C CANOPY, close, lock and check all canopies.
B BRAKES, check the functioning, close and lock for take off.

Then give the order to have the cable attached and on the first flight of the day test the release. It is essential that the cable is not attached until the pilot gives a definite order so that there is no possibility of the glider being launched before he is ready. Before giving the order to "Take up Slack", make quite sure that it is all clear ahead of the aircraft; that there is no one in front or near the glider other than the wing tip man holding the wing tip level; and make sure that there are no gliders on the approach by asking if it is "all clear above and behind".

The stick should be held lightly with the right hand and the left hand should be kept near the release knob throughout the launch.

WINCH LAUNCHING

As the cable is pulled tight by the winch, the order "All Out" should be given, just before the glider begins to move. Until the glider is moving along the ground accelerating smoothly, the stick should be held well forward as otherwise any jerks result in the tail skid banging heavily on the ground. By the time that a running speed has been reached, the stick can be allowed to find its own position by holding it very lightly and allowing it to move back. The glider will run on the wheel and leave the ground as a safe speed is reached. At first the take-off attitude should be held as the glider gains speed and climbs away very gradually. It must not be pulled up into the climb or pulled off the ground, and should not be held down and flown level. (Fig. 10.)

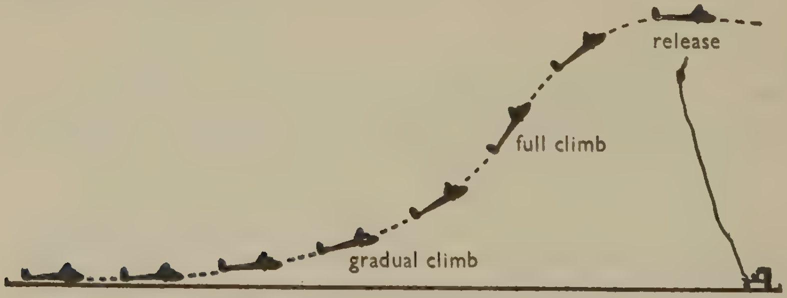


Fig. 10. Winch launching.

After a few seconds a safe speed for the climb should be reached and a gradual climb can then be assumed. The instructor will tell you the minimum climbing speed or in the early stages may just tell you when it is safe to climb. Most training gliders will assume the correct climbing angle for the initial 100 feet if allowed to do so. When a safe height is reached, about three times the height of a hangar, the climb may be gradually steepened by easing back on the stick. The exact angle of climb is not critical once a safe height has been reached.

A gentle climb will result in very little height gained and a very steep climb may result in a cable break unless the conditions are very smooth. The instructor will tell you if the angle of climb is correct and you will gradually learn to recognize the angle without his help.

Near the top of the launch, the cable pulls the nose down from the climbing position, and the ground comes into view again over the nose. If you know the position of the winch in relation to the airfield boundary, a glance at the ground will tell you whether you are nearly over the winch.

The cable should always be released so that it will drop well inside the boundary of the field and in front of the winch. However, it is really the winch driver's responsibility to shut off the power completely when the glider is about 80 deg to the winch and, if this is done, the reduction in power can be felt in the glider and the cable released at that moment.

The nose should be lowered below the normal cruising attitude before releasing so that the cable is not under tension at the time. The release is then perfectly smooth with the glider flying off the cable without any jerk. The release knob should be pulled firmly twice and if there is any doubt whether the cable has fallen, look out to check it.

If the cable is released under tension, the glider will probably zoom into a climbing attitude as the weight or pull of the cable is released. The nose should be lowered immediately to avoid stalling the glider. When the cable is released under tension, the cable may be thrown in a loop round the roller system of the winch, resulting in damage to the cable or rollers and causing a delay.

The moment when the cable is released near the top of the launch is not critical. If the cable is released prematurely, the maximum height will not be gained on the launch, whereas, if you fail to release the cable altogether, the cable will release itself by operating the automatic over-ride part of the Ottfur release.

Obviously, it is vital to keep the wings level during the take-off run or a wing tip might touch the ground and swing the glider badly. Particularly on calm days, full aileron control will not be gained until the glider has run some distance. The correction for a wing dropping must, therefore, be a very prompt and large movement of the control while the speed is low. As flying speed is reached, the controls become more effective and normal movements are all that are required. Provided that the take-off run is directly into wind and the cable has no large bow, the glider will be kept straight by the pull of the cable and little or no rudder will be needed.

As the climb is assumed, it is helpful to look ahead for a cloud to keep heading towards so that any swinging of the nose can be seen immediately. If the wings are held level, the climb will normally be straight towards the winch. Corrections for keeping the wings level in the climb must be made by the co-ordinated use of the ailerons and the rudder. Otherwise the glider will swing off to one side as the correction is made. This effect is caused by the "aileron drag" which is explained in detail on page 65.

If the airfield is narrow or the launches are being made slightly out of wind, look down at the ground to see if the glider is still in line with the take-off run and the winch. A slight bank towards the wind will bring the glider back into line and prevent the possibility of dropping the cable out of the field.

The most common faults in the take off and climb are the failure to keep the wings level and making too steep an initial climb. These faults are easily overcome as the pilot gains experience.

Difficulty in keeping the wings level is often caused by the pilot making a correction to bring them level and then failing to take off the correction at the right moment just before they become level. This fault will be accentuated if the rudder is not used to assist the aileron during these corrections.

The need for a gentle initial climb cannot be over-emphasized and however great the desire for a good high launch, the first part should be identical. It does not suddenly become safe to steepen the climb at a certain height and, therefore, the climb should be a gradual curve until the full climbing angle is reached.

Emergency procedures for cable breaks, etc, will be dealt with later as it is unlikely that your instructor will bother you with details until you have learnt to handle the glider in the air. In the meantime, if the cable breaks, you should lower the nose of the glider immediately and release the end of the cable. Your instructor will then advise you where to land.

MOTOR CAR LAUNCHING

Some gliding organizations launch by towing the cable by car instead of using a winch. This method is ideal where it is necessary to operate from runways, and saves the expense of a winch. From the pilot's point of view the launch is very similar to a winch launch except that extra care must be taken to climb away gently.

This is because the acceleration is not so rapid as on a winch launch so that for a considerable time after leaving the ground the glider has only a small reserve of flying speed. A cable break at this stage needs prompt action and could not be safely dealt with if the glider was climbing steeply near the ground. This danger is further accentuated by the breaking properties of the piano wire which is usually used instead of stranded cable. If the wire has been kinked, it will always break on the following launch. However, unlike winch cable which takes a big load to break it, a kink in piano wire will often break during the take-off run or the initial gentle climb before a big load is applied. The pilot must, therefore, be especially alert for this possibility.

It is sometimes necessary for the towing car to change gear just after the glider leaves the ground, and this causes a momentary loss of speed which could be disastrous in a steep attitude. Since the wire is not being wound in, there is no hurry to gain height at first and with car launching the glider continues to climb all the time until the moment that the car slows down at the end of the run.

Eleven or twelve s.w.g. piano wire may be used instead of stranded cable, and since it is very easily kinked or tangled, special care must be taken in light winds to release it promptly when the car slows down. Then the car has room to continue towing until the cable parachute touches the ground with the wire laid out straight.

A powerful truck with an automatic gear change is ideal, and Ford F100s have been used at Lasham for many years. For the maximum rate of launching two wires and two cars are used. Another variation is to take the wire round a large pulley mounted at the end of the runway so that the car drives towards the launch point and has the whole length available. After the glider has released, the car continues to the take off point to drop the wire ready for the next launch. (Parachutes, etc., are fitted to both ends of the wire.) This method gives much higher launches with little additional trouble.

CHAPTER 6

THE APPROACH AND LANDING

How to make the approach and landing—Correcting bad landings

A GOOD approach is necessary as a basis for a good landing, and a bad landing can usually be traced to a faulty approach.

Judgement of the approach can only come with practice, and in the first attempts at landings your instructor will plan the circuit and approach for you so that you can concentrate solely on the landing of the glider.

A good approach is one in which the glider completes its final turn into wind at a safe height and then approaches steadily at a suitable speed onto an unobstructed landing area.

Owing to the errors inherent in the altimeter, it is wiser to judge all heights below 300–400 feet. This is not difficult as in most cases the height of the glider can be compared with nearby trees or buildings. The final turn should always be completed by the time that the glider is down to the height of very tall trees, or about one and a half times the height of a house or hangar.

In very turbulent and windy conditions, the final turn should be completed 200–300 feet above the ground whenever possible. Since the ground speed will be very low gliding into the wind, a high final turn does not mean landing far up the field.

The minimum speed for the approach should be at least 10 m.p.h. above the normal cruising speed, and considerably more in windy conditions when the "wind gradient" is more marked. (See Chapter 16 for a complete explanation of "wind gradient".)

After the final turn, a straight approach should be made into wind. The effects of any turbulence tipping the glider must be corrected immediately to keep it flying straight, and a steady attitude must be held all the time.

In order to judge the height of the glider above the ground during the hold off and landing, it is essential to look well ahead. Unless you look well ahead, the glider will fly into the ground before you have had time to appreciate the change of height and make a correction on the controls.

A similar problem occurs if you drive a car at high speed in poor visibility. It is difficult to see that the car is not going straight until a serious error has been made.

A very slight backward movement should be made near the ground to check the glide, so that it is flown level and just off the ground while it loses speed. The glider should then be kept off the ground by gradually moving back on the stick until it sinks the last few inches onto the main wheel. (Fig. 11a.) After touch down, the glider must be held straight with the wings level until the landing run is completed. If the landing area is rough, it is best to hold the main skid off the ground as long as possible after landing by making a gradual backward movement on the stick.

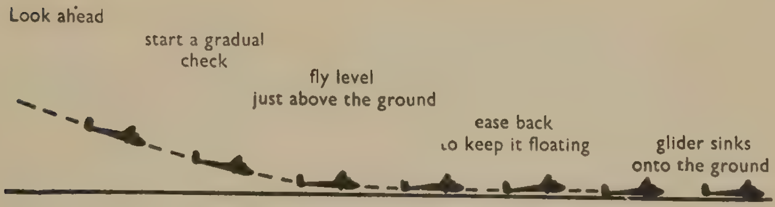

Look ahead
start a gradual check
fly level just above the ground
ease back to keep it floating
glider sinks onto the ground

Fig. 11a. The approach and landing.

At first the main difficulty will be flying the glider straight on the approach. Your reactions are bound to be slow, and this means that when a wing drops, the glider will have turned off course by the time you have made a correction. You will overcome this fault as you gain experience, and every beginner finds the same difficulty.

If too large or quick a movement is made to level off from the approach, the glider will climb or balloon instead of just flying level a few inches above the ground. When the glider balloons above about five feet, a very slight forward movement is required to put the glider back into a safe attitude and then another landing must be attempted farther up the field. The check will need to be made with a slightly greater movement on the elevator because by then the speed will be much lower and the controls less effective. If only a slight ballooning occurs, there is no need to lower the nose, as a

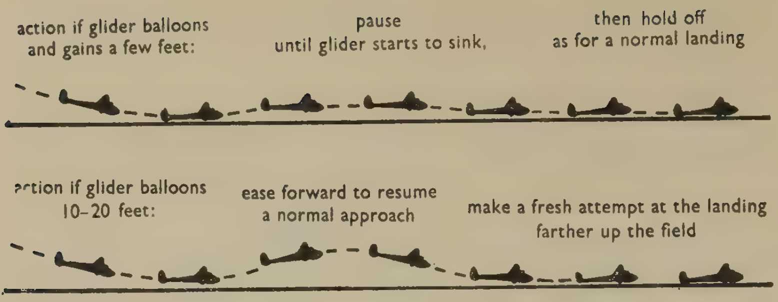

action if glider balloons and gains a few feet:
pause until glider starts to sink,
then hold off as for a normal landing
action if glider balloons 10–20 feet:
ease forward to resume a normal approach
make a fresh attempt at the landing farther up the field

Fig. 11b. Corrections for bad landings.

pause will allow the glider to sink and the check can be completed to make a normal landing. (Fig. 11b.)

Do not be in too much of a hurry to get down. Providing that the glider is within a few inches of the ground, the longer it is kept off the better.

Ex-power pilots should note that ideally the glider should touch down on the main wheel and tail skid and not in the fully stalled attitude which would result in a landing on the tail skid. They will notice that the initial check and hold off are made much nearer the ground than on a powered aircraft.

After touch down, look straight ahead to the horizon and keep straight towards a definite object on the far boundary. Slight swings will otherwise go undetected until it is too late to prevent a violent swing with possible damage to a skid.

Landing is a matter of practice and there is no easy way to learn. Some pupils find no difficulty from the beginning, whereas others find that the ability to land comes suddenly and unexpectedly, often after ten or twenty apparently hopeless attempts. Most difficulties arise from bad approaches, not looking far enough ahead, and failure to relax resulting in slow and jerky reactions.

The use of air brakes or spoilers on the approach and landing has not been explained because, initially, it is better for the instructor to operate them. Provided that only small amounts are used, they will have a negligible effect on the handling of the controls, and they can be ignored completely until you have learned to land the glider satisfactorily.

Above all it should be realized that no attempt should be made to put the glider onto the ground. The glider should land itself after being held off as long as possible. Considerations such as how far the glider must be retrieved, do not affect the issue. This is largely determined by the height, speed, and positioning of the approach which is normally the responsibility of the instructor in the early stages. First you must learn to make good landings and then afterwards how to make them in the right place.

CHAPTER 7

STALLING AND SPINNING

The symptoms of the stall and recovery action from stalls and incipient spins—The recovery from full spins

STALLING

STALLING is a very important lesson in gliding because in normal cruising flight the glider is flown with a comparatively small margin of speed above the stall. In relation to this margin, the effects of turbulence are large and can easily result in an unintentional stall which could have serious consequences near the ground.

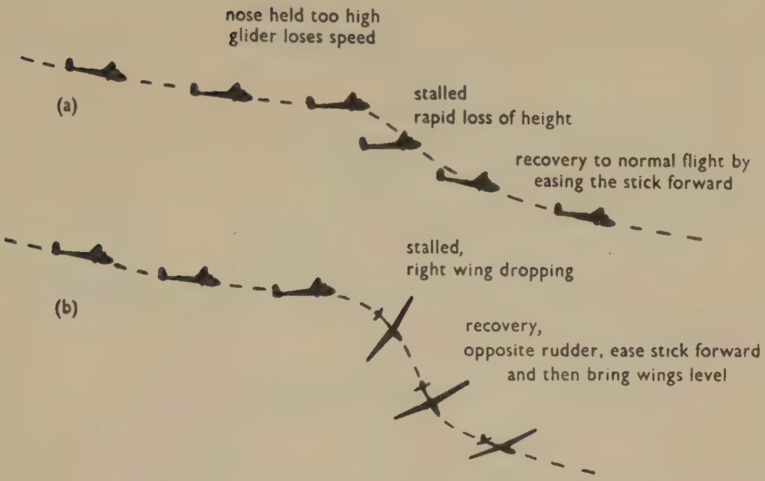
During your training you will practise stalling the glider and recovering to normal flight until you can recognize the approach of the stall without reference to the instruments. Recognizing the stall and making a prompt recovery must become almost instinctive because your attention may be distracted by other gliders nearby or by the ground.

There is nothing dangerous about stalling unless it occurs too near to the ground. For this reason, we always practise stalls at a safe height and we always fly at a higher speed than the normal cruising speed below a height of 300–400 feet.

If the glider is flown with the nose above the normal cruising position (by easing back very gradually on the stick to keep the nose up), the first obvious change is the quietness as the airspeed decreases. After a short while, the nose drops and height is lost rapidly. A further backward movement on the stick will not prevent the nose from dropping as control has been lost for a few moments.

This is the stall.

A relaxation of the backward pressure on the stick, allowing it to find its normal position, is sufficient to help the recovery and, after a few seconds, the nose can be brought back to the normal cruising flight position. (See Fig. 12a.) The stall is normally very gentle unless the nose is pulled right up.


nose held too high
glider loses speed
(a)
stalled
rapid loss of height
recovery to normal flight by easing the stick forward
stalled,
right wing dropping
(b)
recovery,
opposite rudder, ease stick forward and then bring wings level

Figs. 12 a. and b. Stalling and incipient spins.

At first, the main difficulty in practising stalls will be to keep the glider straight, because of the ineffectiveness of the controls at a low speed. Your instructor will point out the symptoms of the stall to help you to recognize it instinctively.

The main symptoms and features to watch for are as follows:

1. The quietness; low airspeed; and lack of airflow on the face, if no windscreen or cabin is fitted.
2. The ineffectiveness of the controls, and temporary loss of control at the stall.
3. The nose dropping, in spite of the backward movement of the stick.
4. One wing dropping in spite of the use of the ailerons. This does not always occur.
5. The rapid loss of height. This is only obvious near the ground.
6. A shuddering of the glider or the controls just before and at the stall.

It should also be remembered that, if the nose is above the normal cruising position, the glider will stall unless prompt action is taken to lower the nose. Prevention of the stall is just a matter of lowering the nose, and this will be effective right up to the moment the glider stalls.

The actual speed at which the glider stalls will be raised when the glider is being turned or manoeuvred in any way or if a heavier load is being carried (such as a heavy pilot). However, for a given all-up weight of glider, a gentle stall will always occur at the same indicated stalling speed. If the correct stalling speed for a particular type of glider is known, the reading of the airspeed indicator can be checked by making a gentle stall. Small errors in the instrument will be noticed and can be allowed for by flying faster or slower by the appropriate amount. The correct speed for normal cruising flight is normally about 10 m.p.h. above the indicated stalling speed.

INCIPIENT SPINS

Sometimes when the glider stalls, one wing may drop. More height is lost than in a straight stall, and there is a possibility of a spin developing if the correct recovery action is not taken. A stall with a wing dropping is known as an incipient spin because it is really the first stage of the entry into a spin. (See Fig. 12b.)

If the wing drops during the stall, apply opposite rudder and then ease forward on the stick to unstall the glider. Immediately the noise of the airflow indicates that normal flying speed has been regained, bring the wings level with the ailerons so that the loss of height is minimized. If the correct action is taken promptly, only a small angle of bank will be reached and little additional height will be lost. A steep angle of bank will probably result in 200 or 300 feet being lost and this would be very critical near the ground.

If the glider is stalled while it is turning, it will usually drop the inner wing. The stalling speed is higher than normal so that, particularly in very steep turns, recovery may be immediate if the backward pressure on the stick is relaxed. This is because at the higher speed, good control is regained the moment that the wings are unstalled.

Particular care must be taken when turning below 500 feet. A safe margin of speed (considering the angle of bank) must be maintained throughout any turn. Because of turbulent conditions and the "wind gradient" effect near the ground, the recovery from a stall during the final turn or approach may take several times as much height as the recovery from a practice stall. (See page 100.) This fact alone accounts for approach accidents in the past costing hundreds of pounds for repairs, quite apart from the risk of injury in this type of accident.

Such accidents would be avoided by increasing speed for the approach at 300–400 feet instead of waiting until the last possible moment. This avoids the possibility of arriving in a position close to the ground at a low speed with the final turn and approach still to be made. When this occurs it is difficult to find sufficient height either to increase the speed or to make a correctly banked turn. In windy or gusty conditions this type of approach results in an accident sooner or later.

Most gliders are unlikely to go into a fully developed spin but, near the ground, an incipient spin is certainly as dangerous and far more likely to occur.

SPINNING

A spin will only develop if the controls are misused while the glider is stalled. The wings must be stalled and the glider must be yawed to make it spin. The prevention of a spin is, therefore, merely a matter of avoiding the stall and checking immediately any tendency for the glider to drop a wing and yaw should an unintentional stall occur.

The entry into a fully developed spin is in two stages. At first the glider drops the wing and falls into a slow spiral. Then after about three-quarters of a turn, if the glider or aircraft is one which will spin fully and no corrective action is taken, the rate of spin increases rapidly until the spin is fully developed. The motion is then automatic and will continue until recovery action is taken. (Fig. 13/14.)

Recovery from the incipient stage is easy and immediate if opposite rudder is applied and the stick moved forward sufficiently to unstall the wings.

The full spin takes much longer to stop, and the recovery action is more critical if a quick recovery is required. The order in which the controls are moved becomes important because there may be interference between the elevators and the rudder in the spin which will reduce their effectiveness.

The correct method of recovery from a fully developed spin must be learnt by heart:

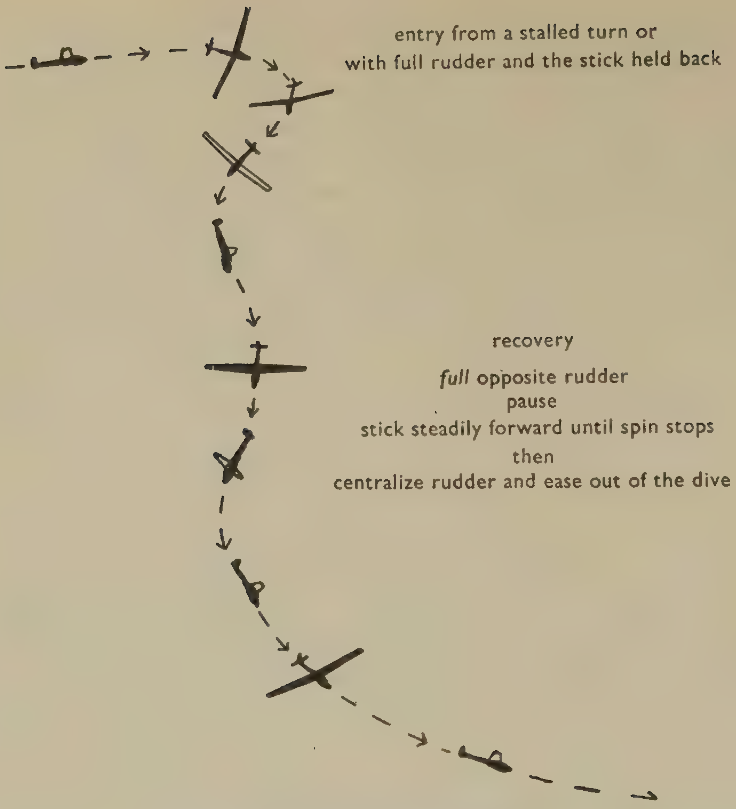

entry from a stalled turn or
with full rudder and the stick held back
recovery
full opposite rudder
pause
stick steadily forward until spin stops
then
centralize rudder and ease out of the dive

Fig. 13/14. The full spin and recovery.

Full opposite rudder — slight pause:
Stick steadily forward until the spin stops:
Centralize the rudder and recover to cruising flight.

(Note. In most gliders recovery is immediate as soon as the stick is released.)

Intentional spinning should not be carried out below 1,000 feet although incipient spins in which prompt recovery is made can be safely carried out down to about 700 feet in some types of gliders.

It is most probable that your instructor will just demonstrate to you one turn of a full spin and will spend much more time on the incipient stage which is much more important. Prompt action in the incipient stage will always prevent a full spin, and a safe airspeed will prevent any possibility of either.

Later on you will receive more training in full spins so that you will become more experienced in making quick recoveries. At first you may find the sensations of spinning disturbing, and this may affect your ability to move the controls correctly to recover. Further practice will soon overcome this, and as you get more experience you will probably find that you gain confidence through the knowledge that you can control the machine in a steep attitude.

CHAPTER 8

CIRCUIT PROCEDURE

Planning the circuit on a flat site—Using the air brakes—Common errors—S turns—Flying from a hill site—An imaginary circuit

UNTIL now we have discussed only the actual control and handling of the glider, and have made little or no reference to circuit procedure or judgement. It is now time to start working out the circuit yourself and at the same time improve the accuracy and consistency of your flying.

The circuit procedure in use will depend largely on the site. It will have to suit the weather conditions, the type of glider and your experience as a pilot. Similarly, the standard of flying necessary for your first solo will depend on the site, so do not feel frustrated if you find that on other sites you would have been allowed to fly solo with half the number of launches.

During recent years many clubs have replaced their older two seaters with faster and more efficient types and this has led to some simplification of circuit procedure. The main change has been to raise the whole of the last part of the circuit and the final turn by about 100 feet so that a longer approach can be made. At gliding sites where the launch height is very limited or low performance two seaters are still in use, less height can be spared for the approach and a much lower base leg and final turn are considered acceptable. The beginner should amend the heights given in this chapter to suit his local conditions.

Right at the start you must realize that in a glider there must never be any question of undershooting as it is impossible to gain height or stretch the glide at will. It is, therefore, necessary to have some sure method of knowing when the glider is getting too far away from the field until such time as your judgement has become good enough to rely on.

One method which is simple to use and understand is to keep the glider within an angle of about 45 deg to the boundary of the field. This angle is easily imagined by stretching out an arm from the cockpit. Flying within this boundary, you can always reach the field in a light wind. In a wind of over 15 m.p.h., however, you should not go as far as 45 deg beyond the downwind boundary.

Gradually, as you become more experienced and fly gliders with a higher performance, you will learn when it is safe to extend this boundary.

* * * * *

Now I am going to discuss flying from a flat site. One of the most important factors controlling the circuit procedure is the height of the launch. This determines whether there is time to search for thermals or practise manoeuvres or whether there is only sufficient height to fly back and land in the normal landing area. Ideally you should be able to judge the approximate height of the launch.

When learning to glide you will find it helpful to say aloud your assessment of the launch before looking at the altimeter to check your judgement. If this is done, there is no chance of having a bad launch and not being aware of it. Also, by saying the height aloud, the instructor knows immediately that you have checked the launch height.

Unless the glider is released in the middle of a thermal it should be flown away from the release point to allow other launches to take place. The direction of the circuit should be determined by the direction of the first turn, since it is very undesirable to fly across the launching line again during the flight.

A common mistake is to turn off at right angles to the launch line. In windy conditions this results in the glider drifting quickly downwind so that it is difficult to avoid arriving back at the launching area much too high. Ideally, in both calm and windy conditions, any search for thermals should be made upwind and to one side of the release point. This leaves more time for circling and gaining height before drifting downwind of the landing area. However, if there are any obvious indications of thermals such as other gliders soaring or cloud forming, fly directly to that area.

During the search for lift, you may fly more or less where you like but you must constantly check your position and height in relation to the landing area.

Your aim should be to arrive back in a position well to one side and a little downwind of the desired landing area at 400–500 feet. This is most easily done by leaving a suitable, chosen position upwind at about 600 feet. (Fig. 15.) This enables a definite base leg to be made so that there is time to adjust the height or position of the final turn. The final crosswind leg is better known as the base leg since it may be at any angle to the wind.

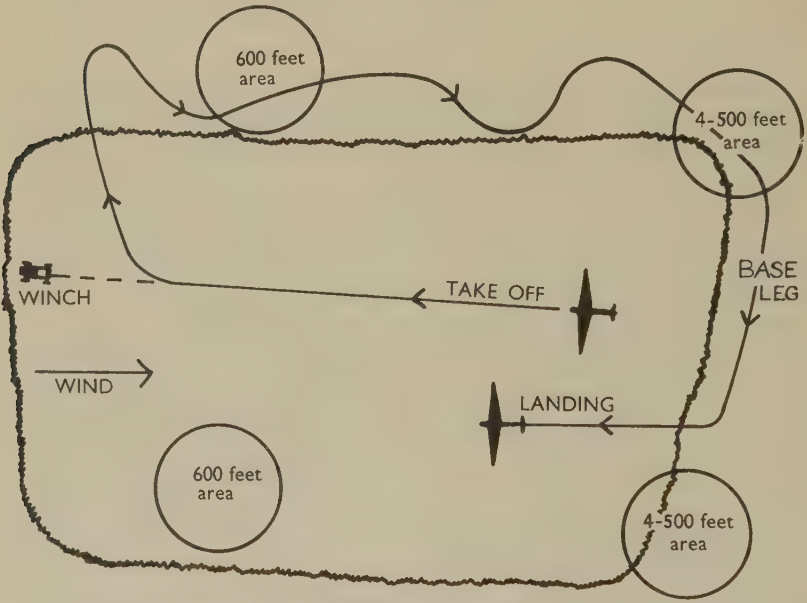


Fig. 15. Circuit planning.

On your way downwind you can use up any excess height by turning out and widening the circuit or by a series of turns from side to side. If on the other hand the glider seems to be losing height rather too quickly, you should turn towards the position you have chosen for your final turn in order to cut the corner off the circuit. In this case, you may have to give up any idea of landing in the normal landing area and turn into wind to make a landing farther up the field.

Lastly, assuming that you have arrived at the 400–500 feet position correctly, you should prepare for the approach. This involves three important changes which should be made at this height even if the glider is not in the ideal position on the circuit:

(1) Increase speed, trimming forward as necessary,
(2) Put your hand on the air brake lever,
(3) Disregard the altimeter and judge your height.

(1) The nose must be lowered to increase the speed by at least 10 m.p.h. for calm conditions, and more in strong winds. This speed should enable a normal hold off and landing to be made easily using any setting of the air brakes. They can then be opened as required to adjust the approach without fear of making a bad landing. The habit of retrimming slightly nose heavy helps the speed to be maintained even if the pilot is tired or distracted. Note that the speed is increased at 400 feet and not just before the final approach. This ensures that, if the height for the final turn is misjudged, ample speed is available for a safe turn near the ground. Otherwise, if the glider is still flying at its normal cruising speed near the ground, there will be no height to pick up the necessary extra speed to make a safe turn. Furthermore, the effects of the wind gradient and turbulence will aggravate this situation. Failure to increase speed in time is the most frequent cause of accidents and heavy landings, since there is no hope of recovery from a stall near the ground.

(2) Put your hand on the air brake lever and keep it there until after the landing has been completed. This is important because when the brakes are needed you do not want to waste time groping for them. Even a few seconds delay will take you another hundred yards down the field. Regardless of the type of glider, your hand should never be taken off the lever once the brakes have been used on the approach. Most types of air brakes will fly open if they are allowed to do so after they have been unlocked. They would cause an undershoot if they came open unintentionally on an approach.

(3) Stop using the altimeter and use your own judgement in assessing the actual height on the base leg and final turn. Below about 400 feet, there is no point in trying to guess the exact height in feet as it is comparatively simple to compare your height with that of tall trees, hangars or other objects nearby. By doing this, you will see immediately if you are getting low. The altimeter suffers from various errors and defects. These are often cumulative and may well be sufficient to result in a dangerous approach if it is relied on below 300–400 feet. It should be completely disregarded below this

height, otherwise you will tend to rely partly on the indicated height and partly on your own judgement. This is essential if you are landing in a field at the end of a cross-country flight, and it is surprisingly difficult to disregard the altimeter once you have come to rely upon it. Practice will soon enable you to judge your height accurately below 400 feet.

Preparing for the approach should be done as a drill: At 400–500 feet, speed up, hand on the air brake lever, disregard the altimeter.

Now you must keep within easy gliding range of a safe landing area and you must complete the final turn onto the approach by a safe height.

You should glance at the landing area throughout the flight but particularly during the final crosswind leg. Make sure that you are keeping within easy gliding distance of the field. It is easiest to judge this by assessing the angle of the landing area to the glider.

The final turn should be completed by at least the height of very tall trees, or about two complete wing spans of height. Provided that the base leg is not too short, you should have plenty of time to look across at the landing area and any nearby obstructions such as trees or buildings in order to compare your height with them. You must decide whether, by the time that you have flown into the position for the final turn, you will have enough height to allow the necessary minimum of straight approach. Normally, it should be necessary to use some air brake at this stage to lose height down to the ideal turning height.

Provided that the decision to use the air brakes is taken in reasonable time, it is possible to use up any normal excess of height by using full air brake. In this way, there should be no need to make an S turn. At the same time, if there is a choice of landing areas, the circuit should be extended by landing in the farther one. Also, the base leg could be made a little farther from the landing area in order to give a longer approach.

If there is no excess height, special care must be taken to keep within easy reach of a landing ground and the final turn must be made before the glider gets dangerously low. In this case it may be impossible to land in the chosen landing area and any attempt to do so may only result in an unwarranted risk being taken.

There is absolutely no excuse for making a dangerously low turn as it is always possible to compare your height with something on the ground and start the turn before the glider gets too low. The most common reason for such an incident is the pilot relying upon the indications of the altimeter and making no attempt to judge the height by looking out. You cannot fail to see that you are getting dangerously low if you look outside the cockpit and use your judgement.

Obviously, the air brakes should only be used on the base leg or final turn when it is clear that there is no possibility of undershooting the landing area and when there will definitely be sufficient height for a safe final turn.

The position of the final turn usually determines how far the glider will land up the field. Fig. 16 shows the effect of the strength of the wind and other factors on the final turn. Ideally, the final turn should be completed just behind the boundary in light winds. Notice that a gentle turn, or a turn at too high an airspeed, will result in the turn being completed too far into the airfield. A gentle turn will take much longer to complete than one with a steeper angle of bank and, therefore, will use up much more height. If you are already

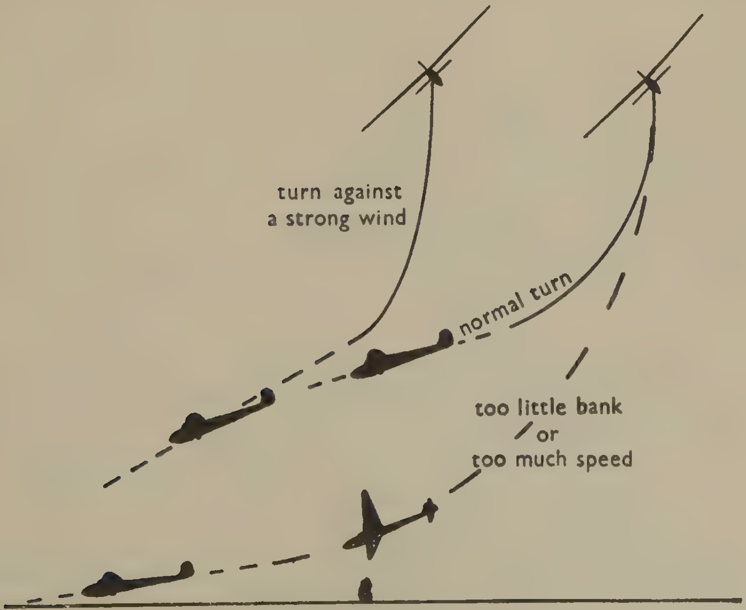


Fig. 16. The final turn.

getting rather low on the crosswind leg, turn into wind immediately using a well banked turn. Do not start a gentle turn or attempt to edge the glider round gradually or you will find yourself still turning when you reach the ground.

A well positioned final turn at a safe height should be the aim of our circuit procedure.

The effect of air brakes and spoilers is to steepen the gliding angle. They also slow down the glider more rapidly if the nose is raised. Not only is the stalling speed raised slightly by the loss of lift over that part of the wing, but the stall will occur quicker because of the rapid loss of speed. With powerful air brakes fully open on the approach, it is important not to level out and hold off too high for the landing or a heavy landing will result.

A satisfactory approach and landing can only be made with full air brake if the approach speed is fairly high.

Ideally the setting of the air brakes should not be changed during the last part of the approach and landing. They must, of course, be closed if there is any tendency to undershoot the landing area and also if the glider bounces badly or balloons high during the landing. Reducing the amount of air brake allows the glider to float farther and gives the pilot more time to make a good landing out of a poor approach or hold off. However, the habit of always reducing the setting of the air brakes near the ground is not to be encouraged as it is not suitable for landing in small fields.

On no account should any attempt be made to stretch the glide during the final approach. If you doubt that you can reach the landing area, open the air brakes and make a landing in any available space short of the boundary. The glide cannot be stretched and any attempt to do so will only result in stalling on the approach.

Sometimes the circuit pattern is upset by a poor launch or an unusual loss of height on the circuit. If the launch is poor and the glider fails to climb normally, check that the air brakes have not opened. If only 500 feet or less has been gained, it is obvious that there may not be sufficient height to get back for a landing in the landing area and that a tight circuit is required.

After a launch like this, you should make a continuous turn onto the downwind leg so that as much height as possible is available for flying downwind.

At about 300 feet, the speed should be increased and the approach planned without regard to landing in the normal landing area. The turn across wind must be made in plenty of time so that a normal approach can be made.

It is most important that the temptation to stretch the circuit by continuing downwind below the normal height for turning across wind should be resisted. This would result in a low slow turn with a risk of the wing striking the ground in the turn or having to land across wind with possible damage to the main skid.

Even with a normal or high launch it often happens that, because of a down-draught, height is lost rapidly on the downwind leg and the approach has to be started half-way down the field.

A poor launch or cable break may end up with lift on the approach and the necessity for using the air brakes or even S turns to avoid a serious overshoot.

It is, therefore, essential to check your height frequently during the circuit and to be prepared to vary your plans according to the situation.

Practise reading the air speed indicator, variometer and altimeter at a glance so that you can read them quickly while continuing to fly the glider accurately.

JUDGEMENT

The development of judgement for landing in a restricted space is largely a matter of experience. Whenever possible several flights should be made on one particular day rather than an occasional flight each month so that you can compare the approaches with each other and rectify any serious errors immediately on the next flight. It is only by the comparison of one flight and the next that judgement is developed.

A constant airspeed is necessary on the approach so that it is possible to judge where the glider is going to land. This is because the glider will float much farther during the landing after a faster approach. Care must be taken not to confuse the attitude of the glider with the actual glide path.

During the approach look towards the desired landing area and watch whether it appears to move under or away from the nose. If it tends to disappear below the nose, the glider is overshooting. (Fig. 17). You must aim for a point about fifty yards short of the desired touch-down position to allow for the glider floating while it is being held off for the landing. However, in windy weather an allowance has to be made for the glider losing height more rapidly than usual during the last 50–100 feet of the approach because of the effects of the wind gradient.

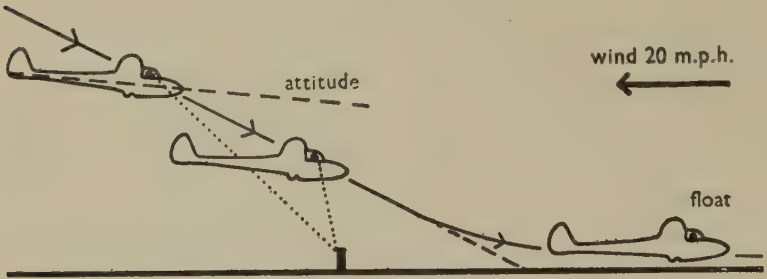


Fig. 17. Judging the approach.

Never attempt to land very close to the boundary just for the sake of saving a few minutes retrieving. No pilot is infallible and however experienced you may be, you will occasionally make errors of judgement or be misled by the conditions at the time. There are quite enough risks in flying without additional ones introduced by relying on perfect judgement. It is particularly important always to remember that there are several ways of losing excessive height but none of gaining height in the event of being too low. This is one lesson you must avoid learning by experience.

If you watch a really experienced and above average glider pilot, you will see that his approaches are always good and that he lands well into the field and not just over the boundary. You will also notice that when he arrives back too low for a spot landing, he is not too proud to land well up the field.

On any but the smoothest landing grounds it is unwise to use the front skid as a brake for every landing by moving the stick forward after landing. The difference in landing run is only about twenty yards and this extra retrieve costs much less than new shock absorber rubbers or a new skid every now and then.

S TURNS

If the glider arrives in the position for the final crosswind or base leg too high, or if it encounters strong lift so that it seems unlikely that the height will be used up in time for a normal approach, it may be necessary to make an S turn. Ideally, the glider should then be flown past the normal turning in point and well beyond it. A turn is made towards the airfield and a new base leg made from that side as though the circuit had been in the other direction in the first place. Care must be taken not to leave the final turn too late or a low turn will result. The turns must not be too gentle or, by the time the final turn is completed, the glider will already be over the landing area and an overshoot will be inevitable. If necessary, a series of S turns can be made but this is not to be encouraged because it makes it difficult for any other glider to make a normal approach at the same time. Also, an approach from a series of S turns tends to be unplanned and is, therefore, not a good way of making a safe landing in a small area. However, if the glider is not fitted with air brakes, or if they cannot be used because of icing, S turns and side-slipping are the only safe ways of using up an excess of height at this stage of the circuit. (Fig. 18).

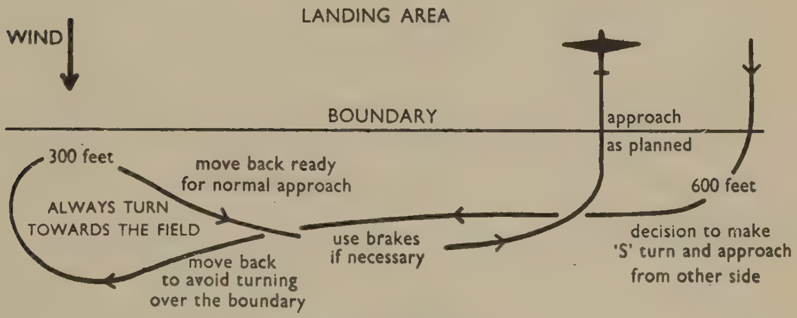


Fig. 18. S turns.

If a thermal is found during the search upwind of the launch point, the glider will be drifted downwind as it circles to gain height. Eventually, the glider will have drifted downwind of the landing area. When it is at an angle of about 45 deg to the boundary, it will be wise to stop circling and leave that thermal in search of another one nearer to the field, or if little or no height has been gained, to rejoin the circuit. It is easiest to join the circuit by flying well off to one side of the landing area and then using up any excess height so that the 400–500 feet position is reached at the right height ready for a normal approach. Unless there is any doubt about reaching the landing area when the thermal is left, do not fly directly towards it. Otherwise you will find it difficult to get into position for a normal base leg without losing sight of the landing area. A difficult approach is almost inevitable if the glider has to be flown either directly over or away from the landing area, in a position where the pilot cannot see it all the time. A long base leg is always preferable to a very short one because it gives you time to judge your height and to use up any excess height with the air brakes before the final turn into wind.

Sometimes, after an unsuccessful search, you may fly through lift after you have left the 600 feet position and are on the way downwind. It is difficult to lay down hard and fast rules for such circumstances, as the experience and skill of the pilot largely determines whether it is safe to attempt to soar at that height. In general, it is not wise to attempt to soar by circling if you are below 500 feet or at any time or position where a sudden loss of 200 feet would put the glider in a dangerous position. This is because in an attempt to soar the turn may be made in sinking air and not in lift, and that will result in a loss of 150–200 feet in the time it takes to complete a 360 deg turn. If the glider is already near or over the downwind boundary of the field, circling is not a safe way to use up height and you should make a small S turn or wriggle, and use the air brakes as early as necessary to ensure that a normal approach can be made.

Never turn your back on the landing area when using up height on or near the downwind boundary.

Lift encountered on the base leg is of no practical use and the best action to take if it begins to upset the original approach planning is to nullify its effect with full air brake. The final turn and approach can then be made as intended.

At first you may be uncertain how far back you should make the base leg. In windy conditions or on sites at the top of soaring ridges, the glider should not be flown behind the boundary. At other times, however, it is always safe to be in such a position that the glider will be over the boundary when the final turn is completed. Obviously, if the glider is too high on the base leg, the approach can be made from farther back. However, it is not desirable to make a very long straight approach because this exposes the glider to the effects of turbulence and the wind gradient for a much longer time with a consequent unnecessary risk of undershooting.

The circuit procedure on a hill site may have to be tailored to suit the particular circumstances.

If the site is at the top of the hill, the approach will be made by leaving the hill lift as low as 300 feet above the field. Because of the likelihood of strong turbulence behind the top of the hill, speed should be increased before leaving the hill lift. The base leg should be made directly over the downwind boundary and not behind it. This prevents any possibility of the glider landing short of the field if a down current is met.

If the site is close to the bottom of the hill, the circuit and crosswind leg should be made beyond the influence of the hill lift if that is possible.

Contrary to expectations, pilots generally have no difficulty in adapting their circuit procedure to any site after a few flights. However, unless you are very experienced, you should always ask for a dual flight at any new site you may visit. This is particularly important at a strange hill site which is likely to have its own peculiarities and dangers.

You may have noticed that I have not mentioned the need for making a "square" circuit. This is because it is often dangerous to attempt to make a neat looking circuit in a glider when the field is small or irregular in shape. The conception of a "square" circuit comes from its use in light aircraft. For the powered aircraft pilot this type of circuit is a good precision exercise which helps to regularize the traffic pattern round the aerodrome. Obviously, the final, base leg should be more or less square to the landing direction whenever possible, but that is probably as far as the square circuit applies to gliding.

The circuit procedure should be as flexible as possible to allow you to look for thermals wherever you wish. You must practise joining the circuit from different positions and heights so that it becomes second nature to position the glider correctly for a reasonable base leg and approach every time. Each flight should be considered as a possible soaring flight and not as a circuit. You will find it just as easy to think of a flexible circuit procedure instead of a square and then you will have no worries when your circuit is upset by meeting your first real thermal.

* * * * *

Now let us consider an imaginary flight together and see how the method is used. (See Fig. 19.)

Just before the flight we must try to decide where the most likely place will be to find a thermal. It will also help to select landmarks on the ground where we intend to be at 600 feet and 400–500 feet for both left- and right-hand circuits. If there is no obvious thermal activity, it is usually best to select the circuit direction which will provide the easiest approach. In Fig. 19, the right-hand circuit avoids making the final crosswind leg over the tall trees and the final turn is much less than a right angle.

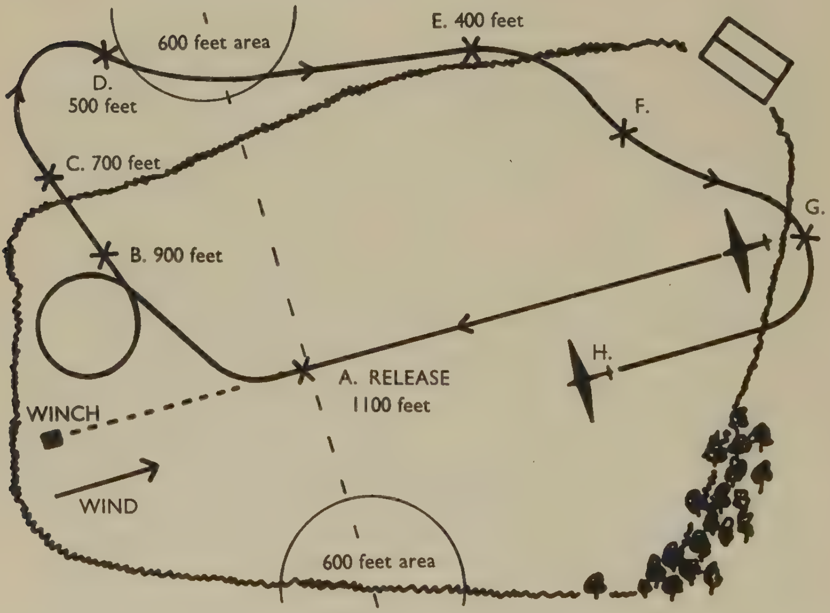


Fig. 19. Imaginary circuit (see text).

"A good launch, about 1,100 feet." You comment (A). A glance at the altimeter shows your estimate to be approximately correct. After settling down at normal cruising speed you look around and then turn about 45 deg to the right to leave the line clear for the next glider to be launched.

As there is not much chance of finding a thermal today, it is an opportunity to practise turns. Look around, bank and rudder, and now you try to keep a perfectly steady turn. Glance at the height—900 feet (B). You still have about 300 feet to use before worrying about getting home and you decide to do a practice stall. You do not want to cross the line through the 600 feet area until you have used up that height or you are certain to arrive in the approach area much too high; 700 feet—it is time to turn downwind (C). Now you can confirm the choice of the 400–500 feet position. This should be well to one side of the landing area (say 400 yards) and slightly beyond it. The hangar will do for this circuit.

Now (at D), owing to unexpected sink, your height is about 500 feet and you set off downwind towards the hangar; 400 feet and the hangar is still some distance away (E). You decide to cut across towards the turning-in point to conserve your height.

Speed up; hand on the air brake lever and disregard the altimeter (F). You definitely will not need the brakes until the final turn is completed this time and you may even have to turn in to land earlier than you had planned. No, a friendly patch of lift helps you on your way and now you are able to move back safely for the final turn (G). This gives you the approach you had hoped for and you can open the air brakes to bring you down comfortably inside the landing area (H). A quick glance at the airspeed indicator assures you that the approach speed is correct and you continue to make a good landing. (Notice how the ideal, long base leg has had to be sacrificed in order to reach a position for a satisfactory final turn.)

CHAPTER 9

CABLE BREAKS

Action to be taken at various stages of the launch

THE glider pilot must always be alert to the possibility of having a power failure or cable break during the launch.

A knowledge of exactly what to do together with practical experience of real or simulated cable breaks at the most critical heights should enable an *ab-initio* student to fly solo without the slightest apprehension.

It must be realized that safety on the launch depends on a correct take off and initial climb and on being mentally prepared for a break on every flight. The actual frequency of cable breaks depends on the state of the cable and the conditions. It is not unusual to have a break once every 50–200 launches.

ON TAKE OFF

Sometimes, through carelessness, the winch driver may snatch the glider so that it overruns the cable. If this happens, there is a possibility that the parachute and rope may tangle round the skid or wheel axle so that it cannot be released. If the cable has not broken and the launch is continued, the climb will tend to become dangerously steep and at the top of the launch the winch or car driver will have to cut or release the cable from his end. In practice this occurs very rarely but the risk is always present if the glider overruns. It is, therefore, necessary to know what to do in such circumstances.

If the glider runs forward over the rope or parachute, pull the release and shout "STOP". Then hold the stick forward to prevent the glider from leaving the ground or climbing steeply if the launch is continued. This can only happen through a combination of poor signalling and driving. Having stopped the launch, the cable and parachute should be pulled clear of the nose of the glider and a fresh start made.

It is sometimes difficult to see whether the glider has overrun the cable. The signaller and the man holding the wing-tip should, therefore, watch during the start of the launch and give the order "STOP" themselves if this happens. Even if the parachute does not become entangled, the launch should always be stopped immediately the glider overruns as otherwise the slack rope may jerk the glider causing it damage or breaking the cable.

If the cable breaks just after leaving the ground, the nose must be lowered immediately but the air brakes must not be opened unless the airspeed has been checked and is adequate. Otherwise a damaging, heavy landing will occur when, with no brake, a safe landing could have been made.

THE INITIAL CLIMB AND LAUNCH

Provided that a safe speed is maintained and only a gentle climb is made near the ground, it is a simple matter to lower the nose, release the cable and glide down straight ahead to a normal landing. If the field is small or the wind very light, it may not be possible to land in the field going straight ahead from much above 150 feet.

After lowering the nose and dropping the cable, an immediate decision must be made as to whether there is room to glide down and land straight ahead. If this is impossible, or if there is any doubt, the glider should be turned across wind. You can then decide whether from this new position there is room to turn into wind and land or whether a circuit must be made. (Fig. 20.)

It is important not to dither while still flying into wind because the available landing space is getting shorter every moment. Once the turn has been made, the space remains more or less the same and a quick decision is less vital.

When a circuit is made, the turn should not be too gentle. If there is sufficient height, it may be possible to fly a little way downwind before making the approach. Remember that a cable break is an emergency and you are not expected to try to land back in the normal place.

It should be noticed that the decision to go straight ahead or make a circuit cannot be safely based on the height indicated by the altimeter. If the instrument had not been correctly set before take off, or was not reading accurately for some reason, you might make a wrong decision with serious consequences. Furthermore, if the amount of field remaining ahead after the cable break is small, a low circuit may be the only possible action although the height available may be far less than normally considered the minimum for safety.

Unless there is obviously plenty of height for a circuit, the safest course of action is to say to yourself: "Can I go straight ahead?" If so that is the safest action to take.

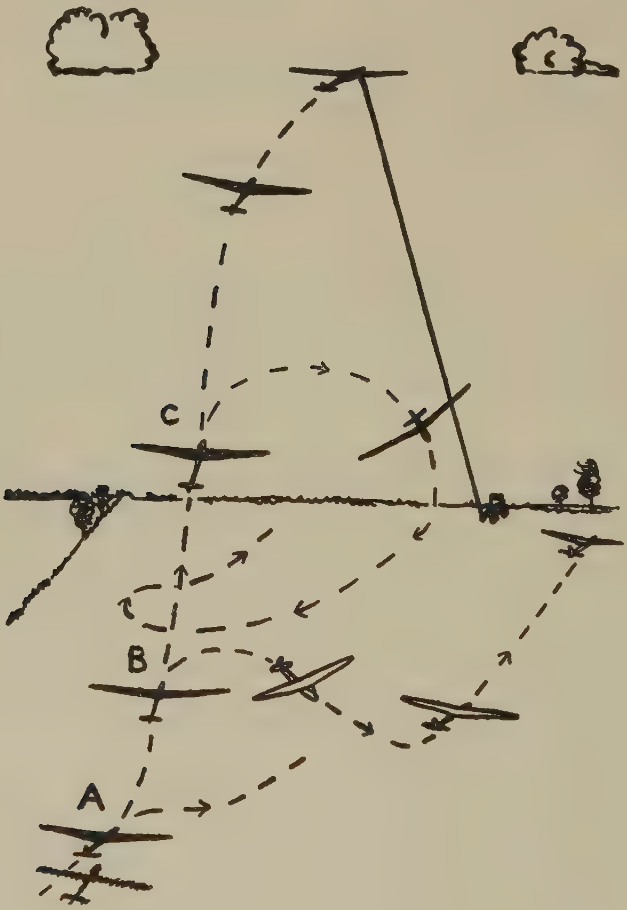


Fig. 20. Cable break procedure.

a. Glider lands straight ahead.
b. Insufficient room to land straight ahead—make an S turn and then land ahead.
c. Ample height for circuit or insufficient room for an S turn—make a 360 deg. turn and land.

If it is obviously impossible to land ahead or if there is any doubt about it, turn across wind immediately and *think*:

"Can I turn into wind now and land ahead or make an S turn?" If so, turn into wind and land. Otherwise keep turning and make a circuit and then land into wind.

Often although the nose is lowered immediately the break occurs, the glider is still flying slowly and takes some time to regain a safe approach speed. Do not use the air brakes UNTIL the approach speed has been reached.

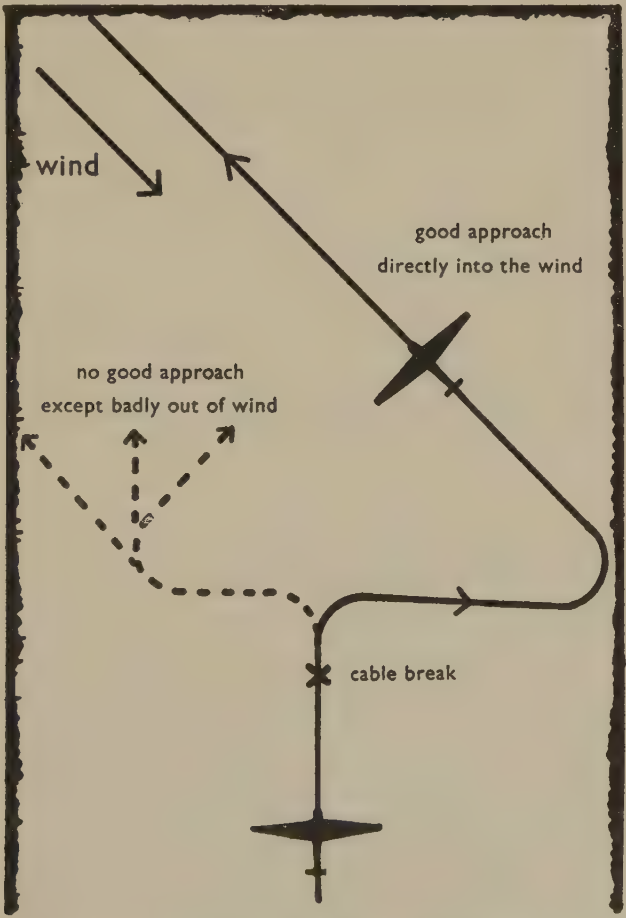


Fig. 21. The advantage of turning first to the downwind side of the field if the cable breaks.

It is always a good idea to consider the shape of the field and the positions of any obstructions before taking off. In many cases there is much more room to land ahead if a turn is made in one particular direction. When the wind is across the launching line, it is usually best to turn to the downwind side so that if you decide to turn into wind again, a long run is available without the need for landing out of wind. (Fig. 21.)

It is possible that following a cable break, or at some later date, landing in a field, you may find yourself very near the ground and getting close to the upwind boundary of the field. If possible, turn for the largest run free from obstruction and fly the glider on to the ground smoothly without holding off sufficiently for it to float. Having landed, the stick can be moved forward to use the front skid as an emergency brake. If necessary, push the wing on to the ground with aileron and apply full rudder to swing the glider round. This manoeuvre is commonly known as a "ground loop" and will usually result in damage, but this is better than destroying the glider by running straight into a solid object.

The most critical height for a cable break is from 0–300 feet. Be prepared and have your plan of action worked out to take advantage of the shape of the field. Make sure you drop the end of the cable. Travelling at 40 m.p.h., the end of the cable is dangerous and it may go across power lines or hit someone.

CABLE HANGUPS

A dangerous situation can occur if the cable is caught or the release jammed. Unless the cable is cut at the other end, the glider will be pulled into a steep dive as it flies away from the release point. To avoid this, lose height by sideslipping and opening the air brakes to get more slack in the cable and then circle the launch vehicle and make the landing near to it. Use extra speed to ensure that the cable will break if it catches an obstruction. If the cable is already pulling the nose down, put the glider into a very steep dive to slacken the cable and to gain speed. Then a fairly rapid pull back to level flight should break the cable. Nowadays, hangups are almost unknown but it is just as well to understand what to do should one occur.

CHAPTER 10

RULES OF THE AIR

Rights of way—Avoiding action

It is now time to become familiar with a few of the international rules of the air. As a glider pilot you must know these and you will be tested on them later when you have made your first solo soaring flight and qualified for the "C" certificate. The full regulations for gliders can be obtained from the B.G.A., and should be read carefully, as they are the law of the land.

When there is a question of one type of aircraft meeting another in flight, powered aircraft should give way to gliders. However, except when the glider is approaching to land, it is common courtesy to give way to powered aircraft, particularly the larger types which cannot manoeuvre quickly.

Aircraft on the ground waiting to take off must always give way to an aircraft in the air.

When two aircraft are approaching to land, the lower one has the right of way. When these are gliders and are both at approximately the same height, the one with the better performance should give way. When two aircraft are approaching head on, and there is a possibility of collision, they should both turn right.

When one aircraft is overtaking another, it should pass by turning to the right (this rule is modified in the special case of gliders ridge soaring. (See p. 155.)

When two aircraft meet on a converging course, the one which has the other on its right must give way.

It should be understood that although one aircraft has the right of way, it is the responsibility of both pilots to take action to avoid risk of collision. It is definitely a shortsighted policy to contest the right of way with other gliders or powered aircraft. The glider pilot should always take action to avoid passing close to other aircraft in flight, unless it is absolutely necessary. Bad air manners can soon make you very unpopular and you will not be allowed to soar amongst other gliders on a crowded site. One careless pilot can endanger all the gliders flying at that time.

Besides the traffic rules, there are regulations controlling flights across airways and controlled air space near the larger airports. Flying in or near cloud is only permitted away from these areas and it is the pilot's responsibility to know the rules and where they apply.

The written test on Air Legislation for the "C" certificate ensures that each glider pilot is aware of the law regarding glider flights in Great Britain.

* * * * *

We have now covered the main things which you will need to know up to the time that you carry out your first few solo flights and qualify for the "A" and "B" certificates. But remember that a book can only be a useful supplement to your flying instructor and cannot replace him.

It is not necessary to include any briefing here for your first solo flights. That is a matter for your instructor. You may have to fly with another instructor for a few flights prior to your first solo in order to put right any habits or faults which may have been overlooked and to make sure that you are ready to go off on your own.

Section II

FURTHER TRAINING AND SOARING

At this stage you may be feeling that you know quite a lot about flying. This is the time when you will learn the need for constant vigilance and care when gliding. Each flight will introduce new experiences and present new problems to be overcome.

It is important to practise stalling, incipient spins and cable breaks regularly so that when the conditions are good you do not have to waste flights on these important practices.

Above all you must set yourself a high standard of airmanship and flying skill.

CHAPTER II

MORE ABOUT TURNING

Why the glider must be banked—The loads and stalling speed in the turn—Aileron drag—Turning efficiently

Turning is by far the most important phase of gliding flight and is the basis of good thermal soaring. It is well worth while trying to learn something about the theory of turning in order to understand how to turn a glider efficiently.

In order to make anything change direction, a force must be applied acting towards the centre of the turn. The size of this force depends on the mass of the object, its speed and the radius of the turn; for instance, with a glider the force required for a turn of 300 feet radius at 45 m.p.h. is equal to nearly half the weight of the glider. This is provided by the lift from the wings when the glider is banked.

Many pilots find it difficult to understand that the rudder plays only a minor part in making a turn. In fact it does not materially

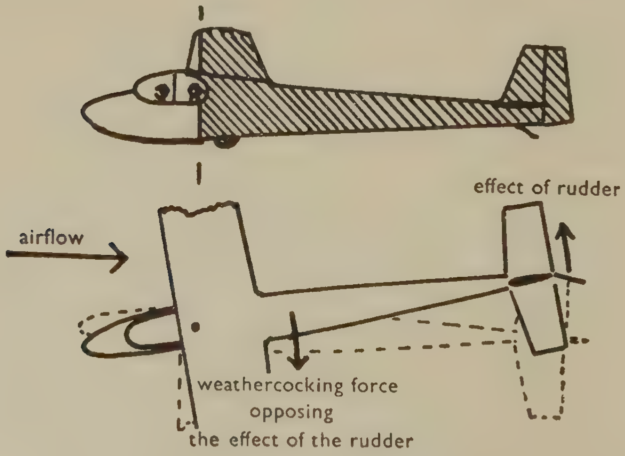


Fig. 22. The effect of the rudder.

affect the rate of turn and is only used to produce the slight yawing force which balances the turn.

Fig. 22 shows what happens if the wings are kept level and full rudder is applied in an attempt to produce a rapid turn. Notice that the force produced by the rudder acts outwards, away from the direction of the turn. When the rudder is applied, the fuselage yaws until the power of the rudder is balanced by the weathercocking tendency of the aircraft (i.e. the tendency for the fuselage to swing into line with the airflow). This leaves the fuselage at only a small angle to the relative airflow which will result in a small force being developed in the direction of the turn. The fuselage moving sideways through the air creates considerable extra drag which reduces the speed and steepens the gliding angle. Flying with too much rudder on is therefore likely to lead to a critical semi-stalled condition from which a spin may develop.

Clearly the rudder is incapable of producing a force equal to half the weight of the aircraft.

In order to understand the need for a combination of movements from all three controls, it is easiest to consider a turn with no bank, one with the wings vertical and then a normal turn of 45 deg of bank. (See Fig. 23.)

A turn with no bank would be entirely a yawing movement. A turn with vertical bank would be entirely a pitching movement and

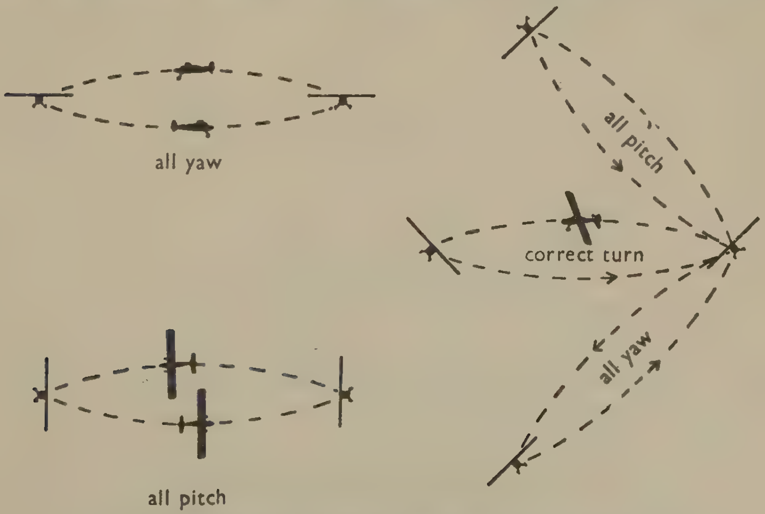


Fig. 23. Yawing and pitching movements in a correct turn.

would resemble a loop on its side. It follows, therefore, that any normally banked turn must be a combination of both yawing and pitching movements.

Before explaining the forces acting on an aircraft in a turn I should explain that for this purpose it will be easier to consider a powered aircraft instead of a glider. This is because a powered aircraft can turn without loss of height, whereas the glider turns in a downward spiral. In the powered machine, the weight is supported by the lift alone, whereas the glider is supported by the resultant of the lift and the drag. These two complications, which scarcely affect the issues involved, do make it difficult to explain a turn in a glider simply and concisely without some inaccuracies. The conclusions are the same for both types of aircraft.

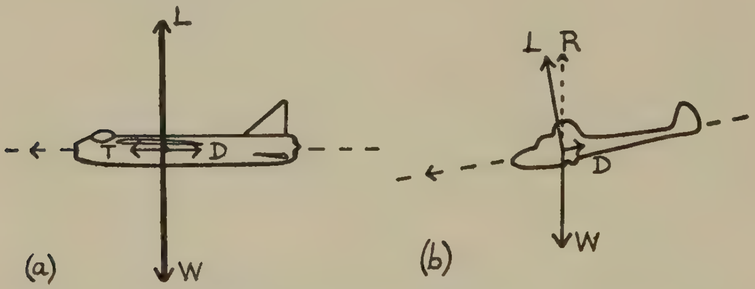


Fig. 24. The balance of forces (*a*) on a powered aircraft in straight and level flight and (*b*) on a glider in a steady straight glide.

When an aeroplane is in straight and level flight at a constant speed, it is in a state of equilibrium and, therefore, all the forces acting on it are exactly balanced. (Fig. 24a.)

The lift *L* equals the weight *W*.
The thrust *T* equals the drag *D*.

Similarly, a glider in steady, straight flight is in a state of equilibrium and all the forces acting on it are exactly balanced.

The resultant *R* of the lift and drag exactly balances the weight. (See Fig. 24b.)

Fig. 25a shows the aeroplane in straight and level flight at a steady speed. The lift *L* is equal to the weight of the aeroplane *W*.

Fig. 25b shows the effect of applying bank alone. Weight still acts vertically downwards (this is always so) but the lift is now inclined. Since the lift force is still the same as the weight, there is insufficient vertical component of lift to support the aircraft and it must, therefore, accelerate downwards and lose height. The resultant of the lift and weight, *S*, causes the side-slipping movement towards the lower wing. More lift is required if a level turn is to be made. This can be obtained by flying faster or by increasing the angle of attack of the wing. If the extra lift is obtained by increasing the angle of attack there will be more drag and a resulting reduction in speed. This is acceptable in a powered aircraft, but in gliders because of the small margin between the stalling speed and normal cruising speed, and because of the need to keep the wing at an efficient angle of attack, the speed may need to be increased slightly in the turn.

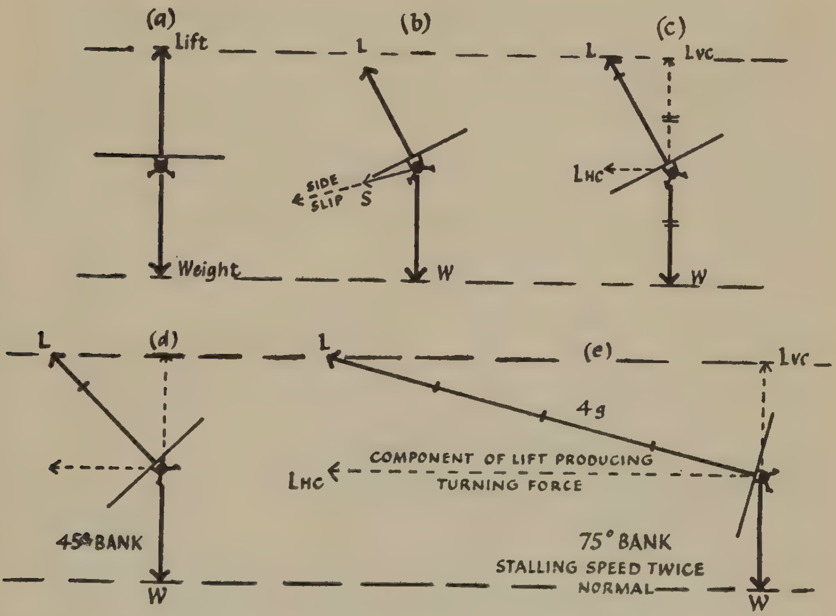


Fig. 25. The forces acting on an aircraft in a turn.

Fig. 25c shows the lift force considered as two components, L^{vc}, the vertical component of lift opposing the weight, and L^{hc}, the horizontal component of the lift. It is the horizontal component which provides the force needed to turn the aircraft. Unfortunately, these diagrams cannot show the need for the yaw in the direction of the turn explained in Fig. 23. Without this yaw, the turn would still be unbalanced even if there was no loss of height. The slip would occur because the aircraft is not directly in line with the relative airflow.

If the bank is increased, the amount of lift required for an accurate turn becomes much greater, until in a vertical bank, no amount of lift will give any vertical component to support the weight. A continuous vertically banked turn is therefore impossible. This fact is often apparently contradicted by high speed aircraft at flying displays. On these occasions, the turns are seldom continued for long enough for any slip to be apparent. The very great inertia of a heavy fighter aircraft flying at high speed enables it to turn for some time before any noticeable slip occurs.

The steepest steady turn obtainable depends on the maximum amount of lift which the wings will provide. In a powered aircraft, this will be obtained with full power (to maintain the speed) and with the wing at the critical angle of attack just below the stall. At this angle of attack the wing gives the maximum lift.

In a glider, extra speed in a turn is provided by steepening the spiral and this results in a greater rate of descent.

Fig. 25d and 25e show that the amount of lift required for an accurate turn increases very rapidly when the bank gets beyond 45 deg. This means that during the turn the wings are supporting an extra load. They must support the weight and provide the necessary force to turn the aircraft. In level flight if extra weight has to be lifted, the aircraft must fly faster to obtain the extra lift. The stalling speed is therefore higher. Similarly, in a turn, the extra lift required means a rise in the stalling speed.

The increase in stalling speed in a turn depends on the increase in the load carried by the wings. This is known as the load factor or loading in the turn and is proportional to the secant of the angle of bank. A loading of twice normal is known as a load factor of two, or commonly as a 2g (twice gravity) turn.

If the loading is four times normal (4g), the stalling speed will be twice normal. (The stalling speed increases in proportion to the square root of the load factor.)

TABLE SHOWING THE VARIATION IN STALLING SPEED WITH ANGLE OF BANK

Angle of Bank	Load on Glider "g"	Increase in Stalling Speed due to Loading
0 deg	1	0
20 deg	1.1	1.05 per cent
30 deg	1.18	8 per cent
45 deg	1.4	18 per cent
60 deg	2	40 per cent
75 deg	4	100 per cent

AILERON DRAG

A further complication to the problem of accurate turning is caused by the aileron drag.

Aileron drag is the term given to the unequal drag of the ailerons while the aircraft is being rolled, for example when initiating a turn. The effect of this drag is to yaw the aircraft in the opposite direction to the banking movements, an undesirable occurrence when the pilot is attempting to turn the glider. This effect of aileron drag is known as adverse yaw.

A movement of the control column to the left to initiate a bank and turn in that direction moves the left aileron up and the right

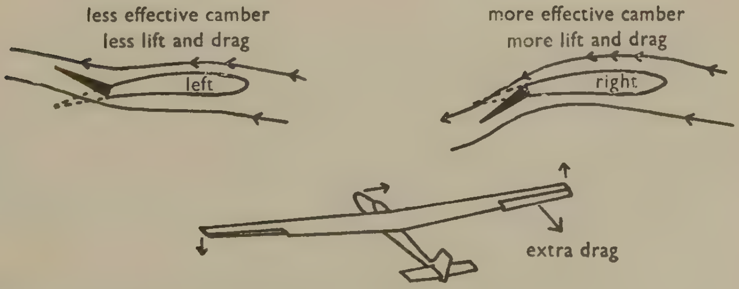


Fig. 26. Aileron drag (banking to the left).

aileron down. Since the whole wing is at a positive angle of attack, the movement of the aileron up reduces both lift and drag on that wing tip by reducing the effective angle of attack and camber. At the other tip, however, the lowered aileron results in greater lift and consequently greater drag. The differences in lift created by the ailerons bank the aircraft, but, at the same time, the unequal drag causes a yawing movement in the opposite direction (Fig. 26). At first this adverse yaw affects the aircraft as a swing of the nose away from the direction of bank. Then, as the aircraft begins to bank, this yawing becomes a swing of the nose above the original attitude. (Fig. 27.) A sideslip occurs towards the lower wing, and then the airflow striking the keel surface of the fuselage when the nose is yawed out of the line of flight overcomes the aileron drag and produces a yaw in the direction of the bank. This sequence of events is most undesirable since it means that the rudder must be used with skill to make accurate turns.

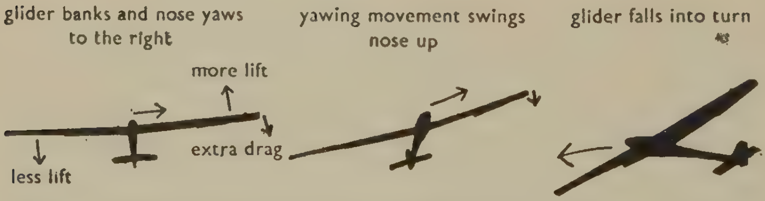

glider banks and nose yaws to the right
yawing movement swings nose up
glider falls into turn
more lift
extra drag
less lift

Fig. 27. The effect of applying bank to the left without using any rudder.

The amount of aileron drag varies with the type of aircraft, but is more marked on gliders than on most modern aircraft.

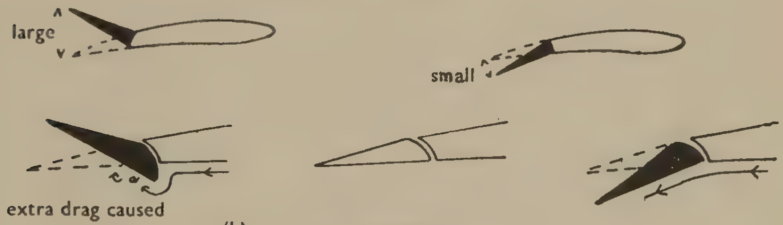
The large wing span of gliders results in any aileron drag having a large moment about the centre of gravity. Aileron drag is unimportant in most modern aircraft because of their relatively short wing spans.

Directional stability also governs how much yaw will occur for a given amount of aileron drag. Many older gliders lack directional stability and rudder movements are needed mainly to overcome aileron drag. Modern powered aircraft are now so stable in this way that normally no rudder is required to turn. This greatly simplifies the problem of handling the aircraft and particularly of learning to fly.

Since the ailerons bank the aircraft by varying the amount of lift developed by each wing, it is inevitable that both wings will develop different amounts of drag. More lift cannot be produced without creating more drag and hence some aileron drag must remain however carefully the aircraft is designed.

The aileron drag can be reduced considerably by arranging for the upward moving aileron to move through a much larger angle than the one which is moved down. (See Fig. 28a.) This arrangement is known as *differential ailerons* and is used on almost all aircraft. Since the down-going aileron moves through only a small angle, it produces some increase in lift but without a very large increase in drag. In practice, the rate of roll is only slightly reduced by the loss in lift caused by restricting the movement of the control surface, but any slight loss is far outweighed by the ease in initiating the turn smoothly.

(a) DIFFERENTIAL AILERONS



(b) FRISE AILERONS

Fig. 28. Differential and Frise ailerons.

Frise ailerons are another method of reducing aileron drag. Fig. 28b shows the principle involved. The aileron is so designed that when it is in the central position or lowered, it fairs into the main aerofoil so that the drag is low. When the aileron is raised, the specially shaped leading edge of the aileron protrudes below the lower surface of the wing, disrupting the flow and creating extra drag. This additional drag helps to balance out the drag of the other aileron and minimize the adverse yaw. The load on the protruding leading edge of the aileron also acts as an aerodynamic balance and reduces the force required to apply full aileron. This helps to make the aileron control pleasantly light and effective. The main disadvantage of Frise ailerons is the risk of ice formation on the protruding leading edge of the aileron. This might jam the control surface or upset the balance of the aileron. The adjustment of this type of aileron is also much more critical.

The amount of aileron drag depends on the amount of aileron applied. This varies with the rate of roll required and not with the angle of bank. If the pilot is content to apply the bank very gradually, he will use only a small amount of aileron which will cause very little aileron drag and need little or no rudder to overcome it. However, if the same angle of bank is applied rapidly, a large movement of the aileron will be used and a large amount of rudder will be needed to counteract the effect of the aileron drag. When the glider is in a steady turn, little or no aileron is needed to maintain the bank and therefore there is very little aileron drag and the amount of rudder must be reduced after initiating the turn.

Similarly, when the glider is coming out of a turn the amount of rudder required will depend on the rate at which the bank is being reduced.

Aileron drag also has an undesirable effect at or near the stall since any attempt to prevent a wing dropping by using the ailerons results in a yaw in the direction of the dropping wing. Also, a large movement of the aileron when the wing is nearly stalled may even cause the airflow over the wing tip to break up and stall with the result that the wing will drop instead of responding normally. Both of these effects will help to start a spin.

* * * * *

Now, it is possible to see why all three controls are required to produce an accurate turn. When the bank is applied, the rudder must be used to overcome the aileron drag and to produce the slight yawing movement needed in the turn. As the angle of bank is checked, this rudder must be reduced. A gradual backward pressure is also needed as the bank gets steeper in order to increase the angle of attack of the wing to provide the extra lift required for the turn.

Any correction on one control will necessitate movements on the other two controls to maintain a steady turn, e.g. if more rudder is applied to correct slip, the yawing movement will lower the nose and tend to cause a further steepening of the bank. A backward movement on the stick will be needed to prevent the nose from dropping and a check movement will be needed on the ailerons to hold a steady angle of bank.

For a steep turn, the speed must either be increased before the turn is initiated or allowed to increase as the bank gets steeper. The backward movement will need to be considerably larger in a steep turn than for a gentle one.

Several other minor effects occur during gliding turns. The outer wing in a turn is always travelling slightly faster than the inner one and develops more lift. However, the inner wing travels less distance for the same loss of height and this results in that wing meeting the air at a larger angle of attack than the outer one. These two effects tend to cancel each other out and are not important. In most gliders it is necessary to prevent the bank from increasing in a steady turn. It is easiest to consider the ailerons as controlling the angle of bank without worrying whether in fact it is necessary to hold off the bank during a turn.

Care must be taken to maintain a safe speed for turning steeply. The steeper and tighter the turn, the higher the stalling speed and the greater speed required for a safe turn. An extra 5–10 m.p.h. should be sufficient for turns of about 50 deg of bank.

If the glider stalls while turning steeply, the wing and nose will drop. Attempts to tighten the turn or raise the nose will be ineffective until the glider has become unstalled by allowing the stick to move forward. Recovery from the stall will then be immediate but height may be lost bringing the glider back to straight flight. For this reason, steep turns should not be practised below about 700 feet except by experienced pilots. Steep turns are an excellent test of piloting ability and should be practised whenever possible.

In a very steep turn, very little rudder is required to provide a properly balanced turn. Almost all the turning movement has become a pitching movement controlled by the backward pressure on the stick. If this backward movement is insufficient to bring the wing to a large enough angle of attack to develop enough lift for the steeply banked turn, a sideslip will occur. This can only be overcome by providing the extra lift required or by correcting the slip with more rudder in the direction of the turn and accepting a downward spiral. Any attempt to raise the nose by using "top" rudder will only create a greater slip and after a few seconds the nose will fall farther in spite of the rudder. This is because the directional stability is much stronger than the power of the rudder. As the aircraft slips towards the lower wing, the airflow strikes the side of the fuselage. The weathercocking action of the fuselage swings the nose down in spite of the rudder. Additional lift is needed to prevent the slipping, and if that is unobtainable the angle of bank must be reduced before it will be possible to raise the nose by easing backwards on the stick.

Contrary to the information in many gliding and flying manuals it is a fallacy to consider the controls as changing their function in a steep turn. Each control keeps its normal effect in relation to the pilot in the cockpit and each control has a proper function in a turn.

The angle of bank is always controlled by the ailerons. The position of the nose in relation to the horizon is always controlled by the elevator, and the sole function of the rudder is to balance the turn by eliminating slip or skid. However, in very steep turns the bank must be reduced before the nose can be raised.

EFFICIENCY IN THE TURN

The glider pilot must always attempt to fly his aircraft efficiently if he is to make the most of any lift he encounters. In a turn this means keeping the aerofoil at an efficient angle of attack and minimizing any losses caused by unnecessary drag. Any inaccuracies such as slipping or skidding will cause an increase in the drag and this will steepen the glide and thereby increase the rate of descent. If the glider is slipping or skidding, the whole side of the fuselage is moving sideways through the air and, in effect, the pilot might just as well be flying along with the air brakes fully opened.

There are few actual flight test results available for gliders in circling flight to confirm how the performance is affected by turning. Disregarding other factors, to keep the wing at the most efficient angle the speed will need to be increased to keep the same margin of speed above the stall as in straight flight, i.e. if the turn raises the stalling speed by 3 m.p.h., the best turning speed for that angle of bank would be 3 m.p.h. above the normal cruising speed. Because of the need for this extra speed, the sinking speed is increased in a turn. The steeper the turn, the greater the sinking speed.

Most gliders have a fairly wide range of speeds over which the rate of descent is almost unchanged and a variation of one or two miles per hour will not upset the performance. However, it does not help to fly very slowly because the glider will become stalled by any gusts and it will be much more difficult to maintain a steady circle. Good handling is essential if the glider is to be kept in the best part of the thermal. Particularly with a laminar flow type of aerofoil, it is more efficient to fly with sufficient speed to avoid the pre-stall buffet caused by the airflow separating from the surface of the wing at large angles of attack than to try to fly as slowly as possible.

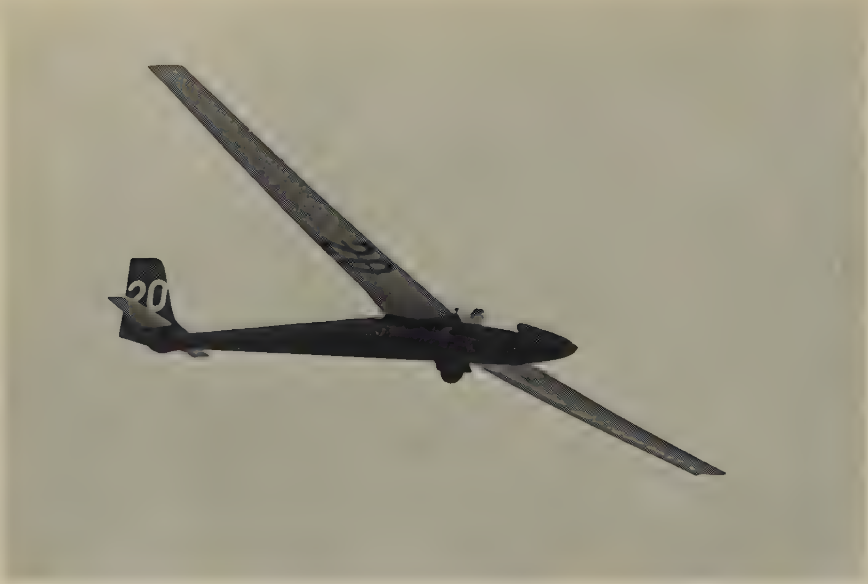
A further complication arises from the size and distribution of the lift in a thermal. Again this is rather a vague and varying factor, but obviously if the thermal is small and strong it will pay to circle in steep turns in order to keep in the strongest lift. In this case, the higher rate of descent in a steep turn is offset by the strong lift. A heavy glider flying at a high speed will be at a disadvantage in these conditions because it will have a large turning radius. The radius of turn depends on the speed and angle of bank. A high-speed aircraft takes a large radius of turn whereas a low-speed glider will be able to turn in a very small radius.

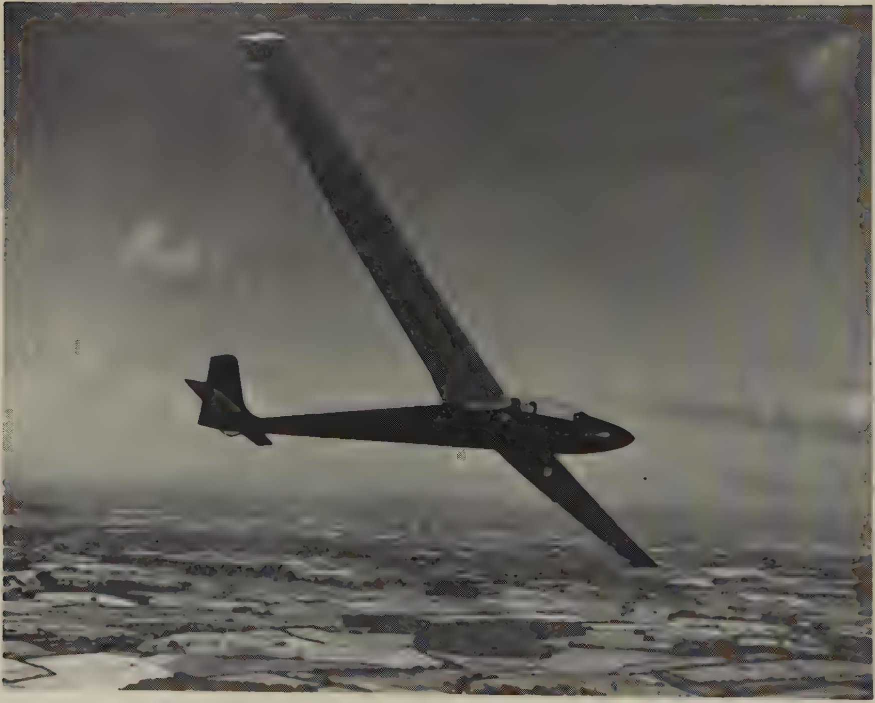
Often when two different types of glider are thermal soaring together the one with the highest performance is outclimbed by the slower but less efficient machine. The lower speed of the latter enables it to turn in the stronger lift inside the turn of the high performance glider. However, this advantage is far outweighed in straight flight when the flatter gliding angle of the better machine takes it a greater distance and gives it more chance of finding another thermal.

The best advice is to adjust the angle of bank and speed to give the maximum rate of climb in the particular thermal. Avoid circling too slowly or at an unnecessarily high speed, i.e. for turns of up to 45 deg of bank, fly at about 2–3 m.p.h. above the normal speed for minimum rate of descent in straight flight. Increase the speed still further if a very steep angle of bank is being used or if the air is very turbulent and it is difficult to maintain a steady speed and angle of bank.

Thermal soaring is excellent practice in handling the glider in turns. In normal thermal conditions it is quite easy for an instructor to get the most inexperienced pupil to make turns in or near any thermal they may encounter and, even if no height is gained, the additional flying time is always valuable. Since thermals are nearly always turbulent, almost constant corrections are needed to maintain a steady turn and speed. This is good practice and also helps the pupil to realize that a high standard of flying is required. The extra time in the air and the height gained (if any) allows the student time to settle down and fly the glider without having to be worried so much about his position relative to the circuit and approach.

If through an error of judgement it is necessary to make a turn near the ground, the aim should always be to complete the turn quickly and the greater rate of descent in a steep turn is outweighed by the reduced time which the turn will take to complete. A gradual turn will take much longer and, therefore, much more height will be lost. However, unless there is sufficient speed to make the turn, a steep angle of bank will only result in a stalled turn with disastrous results. There must always be sufficient speed for the angle of bank being used. A turn with an angle of bank of about 45 degrees will give the minimum loss of height for a complete circle. Too much rudder will *not* increase the rate of turn and will only create extra drag which will result in a loss of speed and a steeper glide path.





Two views of the Slingsby Dart 17R showing the retractable main wheel

Photograph by Charles E. Brown

CHAPTER 12

SIDESLIPPING

Straight sideslips and slipping turns

After the first few solo circuits, you will be taught how to sideslip. This manoeuvre is particularly important if you are flying a glider which has no air brakes, as it may be necessary in order to make a landing in a restricted space without risk of damage to the glider.

A sideslip is a useful way of losing height without increasing speed

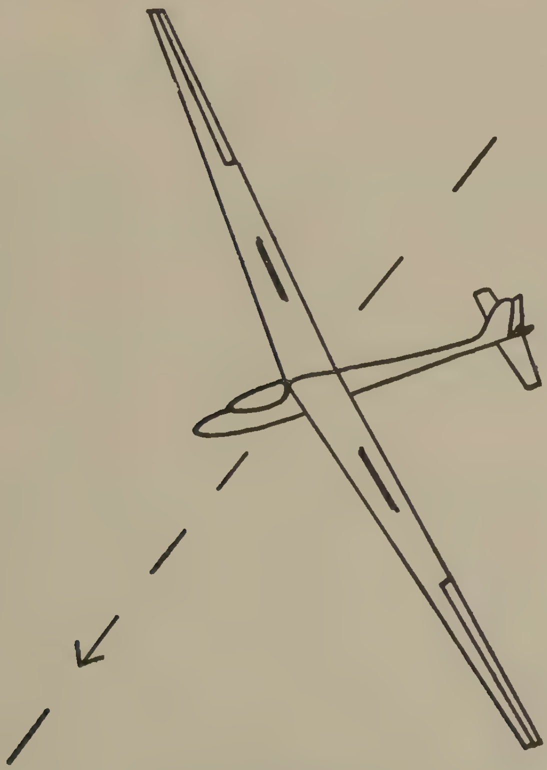


Fig. 29. Sideslipping.

excessively. If the glider is fitted with powerful air brakes there should be no reason to sideslip except in emergency.

There are several slight variations of the normal straight sideslip.

THE STRAIGHT SIDESLIP (Fig. 29)

The glider is put into the sideslip by applying bank and sufficient opposite rudder to keep it from turning. The normal approach speed should be maintained by a slight backward pressure on the stick to keep the nose from falling. Care must be taken not to stall the glider. The rate of descent can be adjusted by varying the angle of bank. The maximum angle of bank in a straight sideslip is limited by the power of the rudder which depends upon the design of the particular glider. In many modern gliders, only a small angle of bank can be held straight and this considerably restricts the value of the sideslip as a means of losing height.

Care must be taken when recovering from a sideslip to relax the backward pressure on the stick or an unintentional stall may occur.

Most gliders are fitted with a pot pitot in the nose and suffer from very large airspeed indicator errors during sideslips. The speed must, therefore, be assessed by the attitude, sound and response to the controls. The noise, however, may be misleading because the turbulence caused by the large angle of yaw may increase the noise round the cockpit.

First attempts at sideslipping should be made in a two seater under the guidance of an instructor.

THE SLIPPING TURN

The slipping turn is a most useful type of sideslip because steeper angles of bank are possible, with a higher rate of descent.

The glider is put into a slipping turn by banking it and using opposite rudder. The angle of bank and the amount of opposite rudder are regulated to control the rate of the turn and the rate of descent. A slipping turn enables height to be lost very rapidly, particularly if the air brakes are being used at the same time.

The maximum angle of sideslip is increased because with full rudder applied a steeper bank can be used since it is not necessary to keep straight. Once again, care must be taken to make certain that there is no risk of stalling the glider by checking the speed frequently to ensure that it is well above normal cruising speed.

Where the glider is a type which cannot be held in a steep sideslip because of the relatively ineffective rudder, alternate sideslips to left and right can be used, changing over as the nose begins to fall through lack of rudder control.

A variation of this, the flat sideslip, or fishtailing, is also a useful way of getting rid of excess height and speed. The glider is yawed from side to side with alternate full rudder, keeping the wings level.

Care must be taken not to continue steep sideslips close to the ground, particularly in turbulent and windy conditions when slight errors in handling together with unexpected turbulence could result in loss of control and an incipient spin.

The decision to sideslip should be taken as soon as it becomes certain that there is too much height. A gentle sideslip can then be started and either steepened or stopped as necessary. Otherwise the glider may eventually arrive in a position so high that only the most violent sideslips would be of any help. In this case, an S turn would have been preferable and much safer.

If air brakes or spoilers are fitted, the need for sideslipping should not normally occur and should be considered as a sign of very poor judgement on the part of the pilot. Both sideslipping and the use of air brakes can make the need for S turns only very occasional if the circuit and the approach are well planned.

Sideslipping is a greatly neglected manoeuvre although it is both pleasing and exacting as a test of handling skill. Every pilot who flies across country should be able to sideslip effectively and for this regular practice is essential.

CHAPTER 13

BETTER LAUNCHES

Launching speeds—Pitching during the launch—The too fast and too slow signals

ALTHOUGH it is easy to fly the glider on the launch, it requires considerable skill and practice to get the maximum height possible on each launch.

Thermals are seldom of sufficient size or strength below 700 feet for an inexperienced pilot to use successfully. A 900 feet launch gives the pilot 200 feet of height to use in search of a thermal which is very little unless the gliding angle is very flat as on a high performance sailplane. An increase in launch height to 1,100 feet will at least double the chance of finding a thermal and a difference of this amount can be obtained with skill.

Since the winch or car driver seldom has an accurate idea of the airspeed on the launch, the pilot must be able to tell him what corrections are necessary to the speed.

The maximum launching speed is printed on the data card inside the cockpit, and the minimum safe speed for good control is about one and a half times the normal stalling speed or about 5 miles per hour above normal cruising speed.

The ideal launching speed varies with the wind strength. In windy weather, the glider will climb up with very little assistance from the winch and the minimum launching speed will give a higher launch because less cable will be wound in. Also, at this speed, the cable and weak link will not be overloaded by the glider climbing steeply through turbulent air, so that the risk of a cable break is reduced.

In calm conditions a higher speed gives the best launch and a poor winch or tow car may have insufficient power to give the ideal launch in these conditions.

Unless the glider pilot signals very promptly to the driver that the speed needs adjusting, a poor start will result in a spoilt launch. However, signals should always be given, so that the winch driver can adjust the speed on the following launch. If you receive a poor launch and make no signals to improve it, you will probably get another similar launch the next time.

The value of accurate launching speeds can be demonstrated by fitting both the gliders and winch with two-way radio. Perfect co-operation is then possible and improvements of 20 per cent increase in launch height in calm weather and 30–40 per cent in high winds have often been obtained even with inexperienced winch drivers. This is largely because of the small time taken to inform the winch of the correction needed. Prompt signalling on the part of the pilot, together with an alert winch driver can effect similar improvements which are of great value on a flat site.

It is important to realize that the attitude of the glider does not control the launching speed and that no attempt should be made to slow the launch down by pulling back hard on the stick as this will only result in a cable break. Unless the winch is seriously under-powered, steepening the climb will result in an increase in launching speed. This is explained in Fig. 30. However, reducing the angle of climb merely results in a worse rate of climb. The best results are obtained if it is the winch driver's responsibility to control the speed in response to signals from the glider. A good driver soon settles down to launching at the desired speed and then signals are seldom needed unless conditions change.

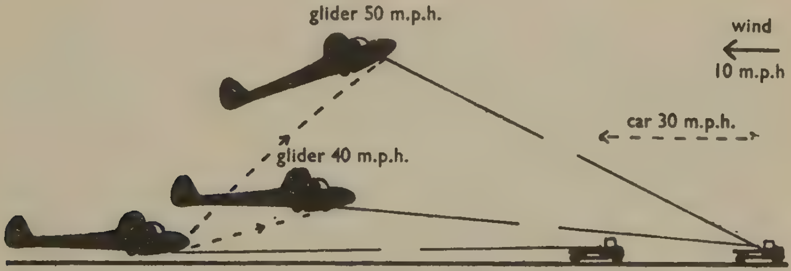


Fig. 30. The effect of steepening the climb on the launching speed. The glider travels much farther in the same time.

The initial climb should always be gentle, becoming steeper gradually as height is gained. If the launching speed is correct, there should be no fear of breaking the cable provided that no sudden jerks are made in assuming the climb. Naturally, a large two-seater glider or heavy sailplane will put a greater load on the cable than a small solo aircraft and, therefore, on gusty days with a large machine it is wise to reduce the angle of climb slightly to avoid unnecessary cable breaks. Quite a large number of breaks, which waste valuable flying time, are caused by climbing very steeply at too high a speed instead of signalling and getting the correct launching speed. This can lead to a rather selfish state of affairs where one pilot obtains plenty of practice at cable breaks while the rest spend their time repairing cables.

A very large percentage of cable breaks are caused by poor piloting and it is noticeable how few cable breaks occur to experienced pilots.

Quite often the glider will pass through, or be launched directly into a thermal on the launch and this can be felt as turbulent air. It will show on the instruments as an unusually high rate of climb and launching speed at the top of the launch. If the launching speed is already too fast, the cable will often break when the glider is lifted by the thermal. It is usually best to complete the climb and then turn back to find the thermal again because, with the additional height, the thermal will be larger and probably stronger. If you do this, remember that other gliders may be waiting to take off. Unless you are climbing quickly above the launching height in the thermal, you must leave the area over the winch without delay.

Some types of gliders have a tendency to pitch unpleasantly near the top of the launch. This pitching motion often begins when the glider flies through bumpy air or if the pilot makes jerky movements on the stick during the full climb. Unless the pilot stops the pitching, it will usually become worse with each successive movement until, finally, the cable breaks.

During the full climb, the elevator is holding the glider in the climbing attitude in opposition to the pull of the cable downwards from the nose. If the cable becomes slack for a moment, the elevator will raise the nose. By this time, however, the slack in the cable will have been taken up and a jerk will occur. This will pull the nose down and slacken the cable. Again the elevator will raise the nose and a second but more severe jerk will occur as the cable pulls tight. In this way, the pitching will get worse and worse as long as the pilot keeps the stick back and tries to keep climbing. (Fig. 31.)

To stop the pitching, the pilot must relax the backward pressure

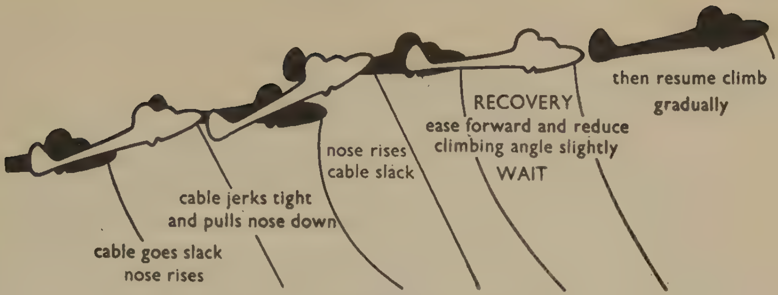


Fig. 31. Pitching on the launch.

on the stick and reduce the climbing angle for a few moments. Time must be allowed for the oscillations of the cable to die out and for the winch or tow car to stop surging and take up the slack in the cable. Then the full climbing angle can be resumed carefully and the launch continued normally. If the climb is resumed too soon, while the cable is still oscillating, the pitching motion will begin immediately and corrective action will have to be taken again.

This pitching or "bucking" as it is sometimes called, is much more severe when the cable release hook is near the extreme nose of the glider. It is also more marked with tow car launches than with winch launches and is made worse if the launch is too fast.

THE TOO FAST SIGNAL

If the launching speed is too fast, the glider should be yawed from side to side by using alternate rudder with the wings held level. Care should be taken not to steepen the climb at the same time or the load will probably break the cable. The signal must be clear so that it is not confused with the swinging about which occurs when a beginner is carrying out a launch. Alternate full rudder should be applied once or twice before continuing a normal climb. The launch speed should then drop as the winch driver makes the correction. If the speed is well above the maximum permissible the launch should be abandoned by releasing the cable.

THE TOO SLOW SIGNAL

If the launch is too slow and the glider is not up to a safe climbing height (100–150 feet), the launch should be abandoned while there is still the opportunity to land straight ahead (remember that it may be a mechanical defect in the winch causing the slow launch or the winch driver may already be giving you full throttle).

At a safe height, the too slow signal should be given by rolling the glider from side to side. This is done by applying about 20 deg of bank in either direction alternately keeping the glider straight. In most gliders it is necessary to use almost full rudder in the direction of the bank to prevent the glider from yawing and unless the glider is held straight and the banking made quite obvious, there is a possibility that the winch driver may be confused by the signal and interpret it as a "too fast" yawing. If the speed is low, care must be taken not to stall the glider while attempting to signal for more speed since any violent rocking of the wings at low speed may cause a wingtip stall and the possibility of spinning. The extra weight of cable together with gusts increases the stalling speed and therefore, when necessary, the nose position should be lowered before signalling. Always be prepared to abandon the launch in case your signals are misunderstood and the driver slows down still more.

It is very tempting to assume that the launching speed will improve so that more height will be gained. Since a power failure or cable break could still occur, there is a very real risk that the glider may be left in a position where it is too low for a circuit and yet has insufficient room for a safe S turn or a landing straight ahead. Do not wait for this to happen!

* * * * *

When the glider has jettisonable wheels, they should be released at a height of about five feet. Below that height there is a risk that they will bounce up against the rear of the fuselage and cause serious damage. If the pilot releases the wheels too soon, or any unusual sound is heard, the take off must be abandoned. Any damage to the fuselage might cause structural failure during the flight.

The attachments for the wheels must be kept clean and straight or there is a risk of the wheels becoming jammed in position or releasing themselves too soon after take off.

The wheels will be damaged if they are dropped above about twenty feet and it is usually better to make the flight and land with them in place rather than drop them from a great height.

CHAPTER 14

LANDING OUT OF WIND

The effects of a cross wind—The crabbing method of crosswind landing—The wing down method of crosswind landing

FREQUENTLY, when landing in a restricted area, it is advantageous to be able to land out of wind in order to obtain the longest run of the field or an approach clear of obstructions.

If the glider is flown across wind, it will not track over the ground in the direction which it is pointing but will "drift" off to one side. If the glider is being flown accurately with no slip or skid, there will be no cross draught in the cockpit. The glider is flying in a mass of air moving at the speed of the wind and is carried with it. (Fig. 32.) If the landing is made while the glider is drifting sideways over the ground there will be a severe sideways load on the main wheel and

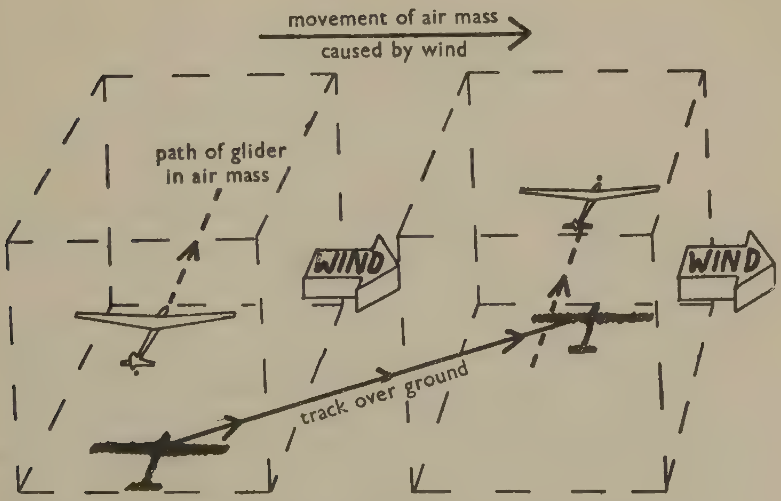


Fig. 32. Flying across wind. The glider tracks sideways over the ground but has no sideways movement relative to the air mass.

landing skid. This may easily break the skid or, if the landing is a bad one, the main wheel fixing and bulkheads may be broken.

After landing, the glider will tend to swing into wind because of the weathercock action of the fuselage. (This is the tendency for the glider to swing into line with the airflow because of the larger amount of side area of fuselage and fin and rudder behind the centre of gravity. This causes the glider to behave in the same way as a weathercock.)

There is also a tendency for the wind to get under the windward wing tip and blow the glider over after landing.

There are two methods of making a crosswind landing, the crabbing method and the wing down method. Each has its particular merits for certain situations, but the first is the most used today and must be mastered by cross-country pilots and instructors as it allows the correction for drift to be left until the last possible moment before touch down.

THE CRABBING METHOD OF CROSSWIND LANDING (Fig. 33)

The glider is turned into the final approach so that it heads sufficiently into wind to track along the required line of landing. The approach is made with the wings level and without any skid or slip, drifting along the desired line. This is continued until the glider is almost about to touch down when the rudder is used to swing the nose into line with the path of flight over the ground.

When the glider touches down, there is no sideways load on the wheel or skid. After landing the glider should be kept straight as long as possible and the "into wind" wing kept below the horizontal. After coming to a standstill, this wing should be put on the ground by using the aileron, so that there is no chance of the glider blowing over before the retrieving crew arrive.

This method has the advantage that it can be successfully used in very strong crosswinds. Care and practice are required to swing the glider with the rudder at exactly the right moment. If the rudder is applied too early, the glider will begin to drift while it is being held off for landing and a further application will be required to avoid landing with drift.

After landing, do not allow the glider to leave the ground or it will begin to drift again.

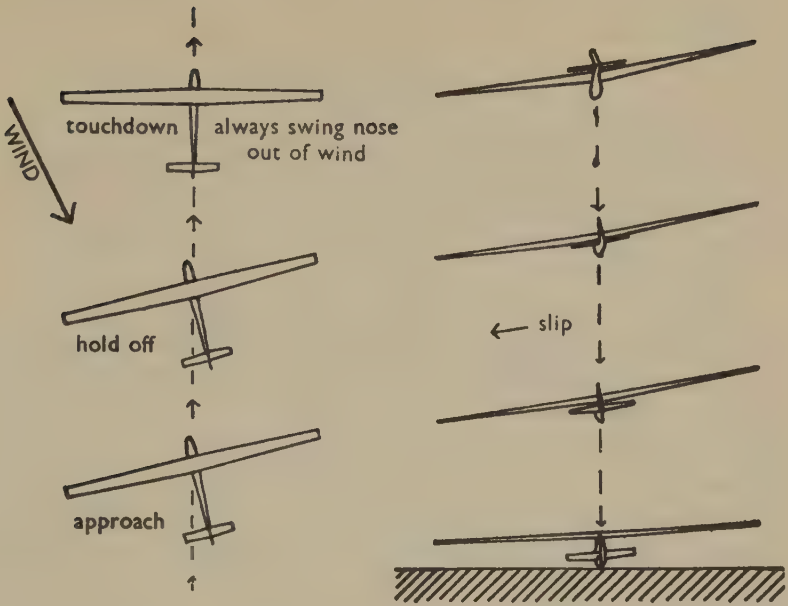


Fig. 33. Crosswind landings. (*Left*) The crabbing method. (*Right*) The wing down method. (Wind from the left).

THE WING DOWN METHOD OF CROSSWIND LANDING

In this method the glider is turned directly into line with the landing line and sideslipped by applying bank and opposite rudder so that this line is made good. As the glider nears the ground, a normal landing is made except that the angle of bank is reduced at the last moment to avoid any risk of touching the wing tip on the ground. The landing is made with the "into wind" wing low and it should be kept in this position after landing, while the glider is held straight.

This method is particularly suited to landing across sloping ground with the wind blowing up the slope. In this case the bank gives greater wing tip clearance which is a great advantage in a glider with a large span low set wing. On flat ground the method has the limitation that only a small amount of bank can be safely used particularly if the sideslip characteristics of the glider are poor. (Fig. 33.)

If the crosswind is very slight, this method is the easiest as it is only a matter of making a normal landing with a little bank applied.

Sooner or later you are bound to misjudge a crosswind landing and land with drift. If the landing happens to be a heavy one, damage will often be caused to the skid, skid fixings or rubber shock-absorber. The chances of such damage can be greatly reduced by making sure that the initial touch-down is made on the wheel (if one is fitted) as this will stand all but the heaviest sideways load without damage. If the landing is made with drift, a violent swing into wind will usually occur and must be prevented by immediate firm use of the rudder.

Unless the landing area is very restricted, the actual approach and landing line can be varied. When landing out of wind, avoid approaching near to obstructions or other gliders so that even if the drift is not fully corrected, there is no danger of drifting too close to them or swinging towards them after landing. In windy conditions it is wise to allow the glider to turn directly into wind at the end of the landing run as it is then possible to balance the wings level until help arrives. This is much safer than finishing out of wind with the possibility of the downwind wing going on to the ground and the risk of blowing over.

In a light crosswind, a normal approach may be made allowing for the glider drifting and then the drift can be eliminated by yawing the nose out of wind so that a landing is made without drift.

There is always a tendency for the glider to bank when the rudder is applied to yaw the glider straight. This must be prevented by using the ailerons to keep the wings level or slightly wing down into the wind. The glider will start to drift seriously if it banks out of wind and a fresh correction would then be required on the rudder to swing the nose of the glider farther out of the wind to eliminate the drift. If the crosswind is strong, it is easier to keep the "into wind" wing low if the landing is made with a slight over correction of drift.

Gliders with the wheel mounted well forward of the centre of gravity have a much stronger tendency to weathercock into wind. If a swing does occur, the mass of the glider being behind the wheel accentuates the situation. Special care must be taken with these machines as, once a serious swing has developed, the rudder may be quite inadequate to keep control. Unless full opposite rudder is applied immediately, the glider will skid right round in a ground loop.

CHAPTER 15

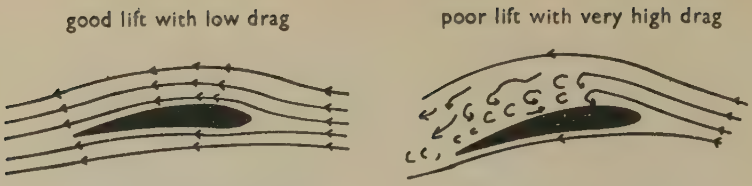
MORE ABOUT STALLING AND SPINNING AND WHY THEY HAPPEN

The stalling of an aerofoil—The normal stalling speed—High speed stalls—The causes of wing dropping at the stall—Auto-rotation—The effects of bad loading and other factors on the spin—Spiral dives—An explanation of the spin recovery action—Inverted spins

STALLING

If the nose of a glider is raised above the normal gliding attitude the increase in the angle of attack of the wing will at first produce more lift and drag. For a few moments the lift and drag may be greater than the weight, and the glider may even gain height. Then the extra drag will slow the glider down, and this loss of speed and the inefficient angle of attack will result in a steeper glide path and high rate of descent. At this moment, there is often a tendency for the nose to fall and for the glider to try to resume normal flight. A further backward movement on the control column will result in a further increase in the angle of attack and a further fall in airspeed. Eventually, the wing will stall and the sudden reduction in lift will cause the glider to lose height very rapidly with the nose dropping.

At small angles of attack the airflow is smooth, and the speeding up and slowing down of the flow above and below the aerofoil creates good lift for only a small amount of drag. However, as the angle of attack is increased beyond the critical angle (generally about 15 deg for conventional aerofoils), a complete change takes place in the flow over the top surface of the wing section. The airflow breaks away from the surface, leaving a turbulent wake with large eddies. The flow over the upper surface is now turbulent and, near the surface, the air may be moving towards the leading edge in places. (Fig. 34.) If the angle of attack is reduced to below the critical, or stalling angle, the airflow will change back, immediately, to the normal smooth, unstalled airflow.



good lift with low drag

poor lift with very high drag

airflow over an aerofoil during normal flight

airflow over an aerofoil during the stall

Fig. 34. Stalling.

Experiments show that the stalling angle is not dependent upon the speed of the airflow. The glider will stall at any speed if the airflow meets the aerofoil at the stalling angle. Unfortunately, the glider is not fitted with an instrument which indicates angles of attack and the pilot must, therefore, know by experience the feel of the glider near the stall. If the glider is stalled by a very gradual backward movement on the control column, the stall will occur when the nose of the glider is only slightly above the normal gliding position. At the moment of stalling, the glide path will be steep and the rate of descent very high. A more rapid backward movement will result in the glider maintaining height until the stall occurs or, if the movement is very harsh, the glider may stall while climbing. In a steep attitude the stall will usually occur at a lower speed and will be more complete. The nose will drop abruptly into a much steeper attitude although the recovery takes about the same amount of height. If the glider is loaded so that the centre of gravity is well forward, the elevator may not be sufficiently powerful to stall the glider except by moving the stick back very quickly. A gradual backward movement on the stick, in this case, results in the glider mushing along at a very low speed, sinking rapidly. If the glider is pulled up into a very steep attitude, its inertia may keep it climbing until it loses all its speed. It may then fall backwards for a few moments in a tail slide.

The speed at which the glider will stall in straight flight, when the control column is moved back gradually so that the speed is reduced at not more than 1 m.p.h. per second, is known as the *normal* or *basic* stalling speed for that glider. This speed will vary with the load carried, or with pilots of different weights.

For example if the stalling speed of a glider which weighs 500 lb empty is 30 m.p.h. when it is flown by a 120-lb pilot, it will stall at over 33 m.p.h. if flown by a 220-lb pilot.

On the first flight of the day, a gentle stall should be made to test the airspeed indicator. The indicated stalling speed will be within 1 or 2 m.p.h. of the correct value unless the instrument has been damaged or has faulty connexions.

Small errors in the airspeed indicator can usually be safely ignored, but if the instrument overreads by a large amount, there is a danger that someone may inadvertently fly the glider too slowly for safety.

During turning or looping manoeuvres, the loading on the glider is increased. This causes an increase in the stalling speed. In a very steep turn or a rapid recovery from a dive, the stalling speed may be more than twice the normal stalling speed for level flight. In this case, the loss of control generally associated with the approach to the stall will be absent, because the glider is not suffering from a low airspeed. However, the pilot will feel the "g" and usually a buffeting of the controls, followed by a lack of response to any backward movement on the control column. Then one wing and the nose will drop, and height will be lost rapidly until a recovery is made. The recovery from a high-speed stall is, however, immediate once the backward pressure on the control column has been relaxed.

During even a gentle, straight stall, one wing may stall slightly before the other so that the wing drops. If this occurs and the controls are mishandled, the aircraft may fall into a spin. There are many causes of wing dropping at the stall.

1. Stalling while the aircraft is turning, is banked, or is yawing.
2. The aircraft being tipped by turbulence during the stall.
3. One wing having a slightly greater incidence than the other because of a warp in the structure.
4. The inherent tendency for a tapered wing to stall at the wing tip first unless some measure is taken to avoid this such as incorporating "washout" at the wing tip.

Most gliders are designed to have gentle stalling characteristics and seldom drop a wing unless the controls are mishandled. The outer sections of the wings are designed to remain unstalled until the last possible moment so that the ailerons will be effective throughout any gentle stall. This is obtained by either decreasing the incidence of the aerofoil at the wing tips (known as washout), or by changing the wing section at the tip to a shape which stalls at a greater angle of attack than the rest of the wing.

If the ailerons are used excessively when the wing tip is nearly stalled, the effective angle of attack of the wing tip is increased by the aileron moving down and this may be sufficient to precipitate a stall at that wing tip. It is, therefore, important to avoid using the ailerons when trying to stop a wing from dropping at or near the stall. In any case, aileron drag will yaw the glider towards the lower wing and this will help to start a spin.

AUTO-ROTATION AND SPINNING

If a wing drops when the aircraft is stalled or nearly stalled, the downward movement of the wing results in a change in the direction of the relative airflow. The angle of attack of the down-going wing will be increased and this may cause it to become stalled, or more seriously stalled than the other wing. The reduction in the lift

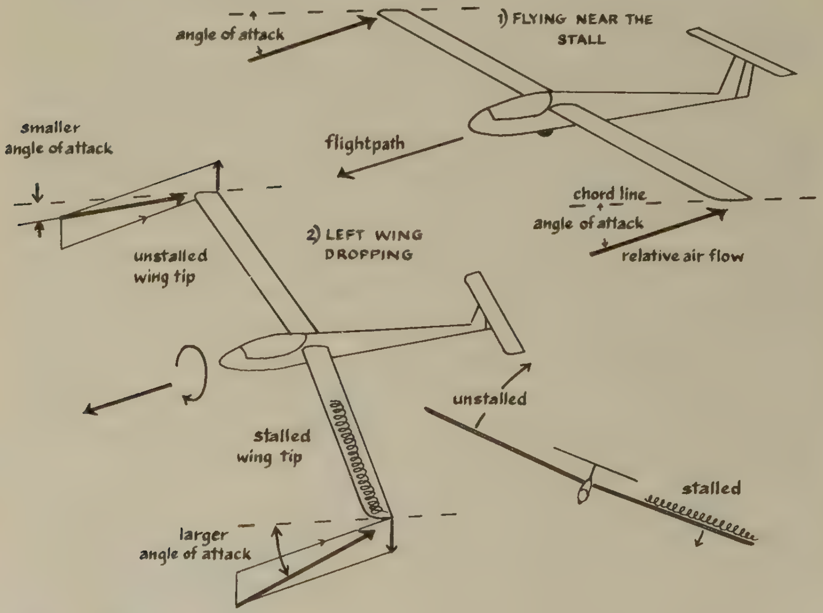
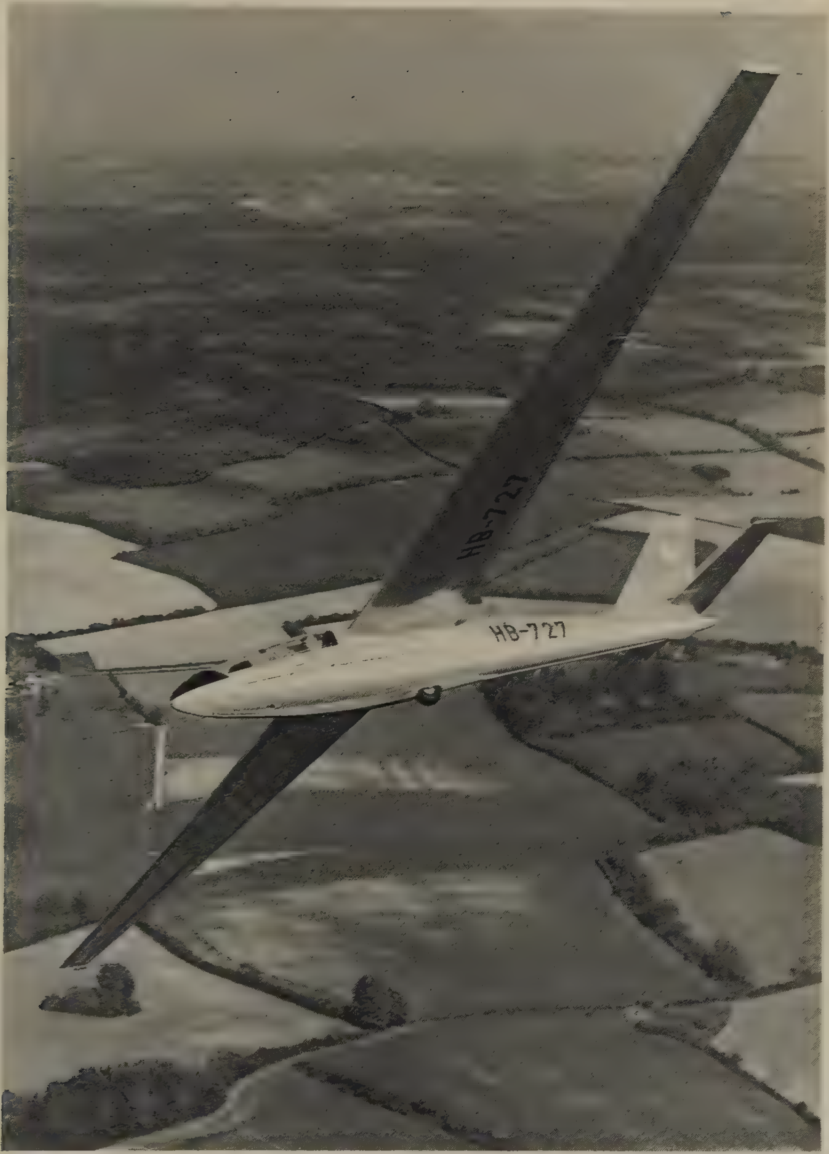


Fig. 35. The effect of one wing dropping at the stall. The glider becomes unstable and starts auto-rotation. In normal flight the increase in angle of attack of a dropping wing results in more lift and stops the movement.



The Polish Foka, winner of the World Gliding Championships in 1965

Photograph by Charles E. Brown

developed by the dropping wing will help to make it drop farther. The rising wing will have a reduced angle of attack and be almost or completely unstalled and will be developing much more lift than the one which is falling. The result of these differences in lift is an unstable rolling movement which is known as auto-rotation. (Fig. 35.) If no other factors were involved, the aircraft would continue to roll until the wings were unstalled. This horizontal spinning manoeuvre is known as a flick roll. However, the effect of the force of gravity acting on the aircraft, together with the nose down pitching moment at the stall, causes the auto-rotation to change from a horizontal rolling motion to a steep diving one.

The uneven stalling of the wings which causes the auto-rotation also results in the wings developing unequal drag. The badly stalled wing has much more drag than the other one. This causes a yawing movement towards the dropping wing which pulls the aircraft into a steep spiral descent which is the first stage of a spin. In most modern gliders, this yawing effect is insufficient for a full spin to develop. Additional yaw caused by applying the rudder or creating a large amount of aileron drag by using a large movement of the aileron may cause a spin to develop.

Whenever the aircraft is stalled and one wing drops, auto-rotation will begin. This is an incipient spin. It is sufficient for only one wing to be stalled to start an incipient spin. If the rate of yaw is sufficient to maintain the spiral and the wings remain stalled, the incipient spin will develop into a full spin. The angle of attack of both wings becomes much greater and the rate of rotation increases. The angle of attack of the wings in a fully developed spin is usually 30–40 deg so that it is much more difficult to unstall them once the spin has developed. Some gliders spin erratically, some steeply, fast or slow. However, most gliders need to be held into a spin or they will recover by themselves.

The spinning characteristics of all modern British gliders are tested during the flight trials, and using the standard method of recovery the glider must stop spinning within one turn, and it must be possible to recover to level flight within 300 feet of initiating the recovery action. Most gliders are very loathe to spin beyond the incipient stage, and will recover if the controls are centralized or released. The correct recovery action is, of course, much more rapid and certain in its effect.

It is not unknown for individual aircraft to have sightly different spinning characteristics. Recovery action should be taken immediately if there is any tendency for the nose to rise progressively during a prolonged spin. Recovery from a flat spin is slow and unpredictable. It is wise to wear a parachute and to have sufficient height to use it if you intend to make any prolonged spins. (There is seldom any reason to do this unless you are testing a new type of glider.)

If the centre of gravity is too far aft, it will be easier to put the glider into a spin and much more difficult to make it recover. In effect the extra power of the elevator will enable the wings to be stalled to a greater angle and the spin will become flatter. However, when it comes to the recovery, the elevator will have to overcome the tail-heaviness and, therefore, the recovery will be more difficult. In some gliders, the position of the centre of gravity is critical and on no

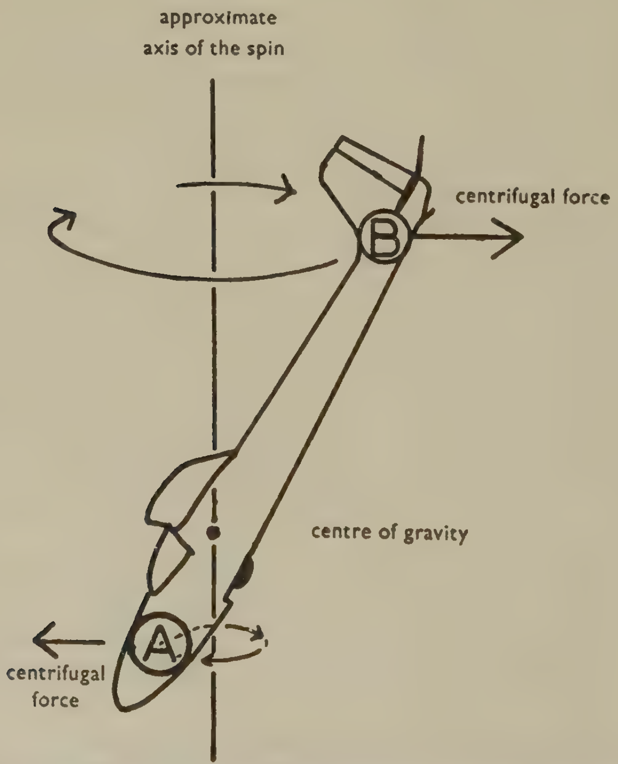


Fig. 36. Spinning. If the glider is considered as though its weight was concentrated at A and B, the effect of an increase in yaw becomes clear.

account should the glider be flown with too light a pilot or it may be impossible to recover from a spin. The placard in the cockpit states the minimum load which may be carried. Usually this is 120 lb for a solo glider.

A large yawing force provided by a powerful rudder or a large amount of aileron drag, will speed up the rotation and this will tend to flatten out the spin. Any flattening effect will increase the angle of attack of the wing and make the recovery more difficult. Fig. 36 shows why an increase in the rate of yaw flattens the spin. As the rotation increases, the centrifugal force produces a nose-up moment which prevents the nose from dropping and unstalling the wings. Conversely, during the recovery, any reduction in the rate of yaw will help to allow the nose to drop which will help to unstall the wings.

The effect of having the spoilers or air brakes out during the spin will vary with each design of glider. Usually, they help the recovery and prevent an excessive speed being reached in the dive. Air brakes should always be opened immediately after the spin has stopped if the glider is in cloud.

Unlike a steep diving turn, or spiral dive as it is generally known, the speed remains low in a spin. This is the most distinctive feature when recognizing a spin from the instruments.

Sometimes the elevator is unable to keep the wing stalled beyond the incipient stage of the spin. In this case, as the nose and wing drops, the wing will unstall and the speed will increase with the glider in a spiral dive. (Fig. 37.) The glider is no longer spinning and is not stalled. Recovery to level flight can be made using all three controls normally.

Prompt action is the key to making a rapid recovery from an incipient spin and this is largely a matter of keeping in practice.

The opposite rudder is used to check the tendency for the glider to yaw towards the dropping wing. Unstalling the wing will eliminate any possibility of auto-rotation and prevent a spin. The wings must be brought level quickly if the minimum of height is to be lost and, since by then the wings are unstalled, the ailerons should be used for that purpose. The rudder will not pick up the wing at this stage as the glider is sideslipping steeply and the weathercocking action of the fuselage overpowers the effect of the rudder. Note also that the rudder is not used to raise the dropped wing in the recovery action. It merely checks the yawing tendency slightly.

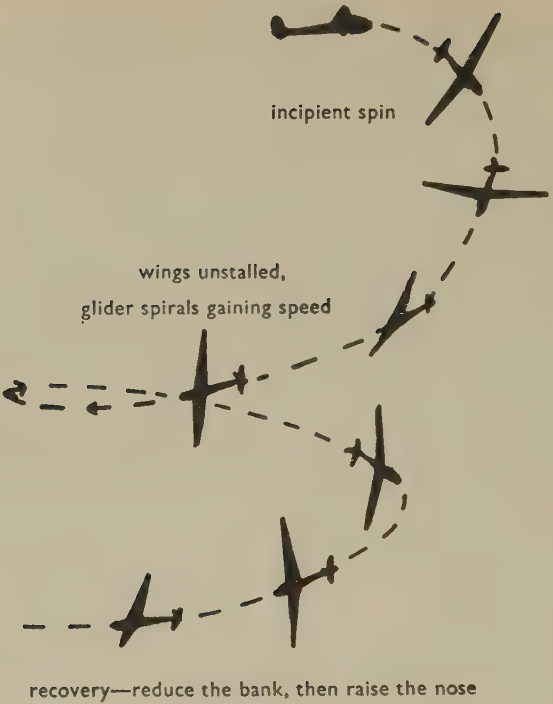

incipient spin
wings unstalled,
glider spirals gaining speed
recovery—reduce the bank, then raise the nose

Fig. 37. The recovery from a spiral dive.

It is very important not to attempt to raise the wing with the aileron while the wing is stalled. The increase in the effective angle of attack of the wing when the aileron is lowered will tend to stall that wing more and help the auto-rotation. The aileron drag will also help the yawing and at the very least, this will delay the recovery and cause precious height to be lost. The correct use of the controls at this time is not instinctive, and plenty of practice is needed if the right action is to be taken in an emergency. Prompt action can always prevent a spin from developing, even if the corrective action is applied after the wing has dropped.

The recovery from a fully developed spin is important, but it should be remembered that only gross mismanagement of the controls and very slow reactions on the part of the pilot will make the average glider go beyond the incipient stage.

The order of the control movements is important. It is arranged to minimize any possible blanketing effects of the tail plane and elevator on the rudder. The amount of forward movement on the stick required to stop the spin varies with the aircraft and the stage of the spin. It is best to think of the forward movement as being a steady, progressive movement continuing *until the spinning stops*. In most gliders, the spin may stop after only a small forward movement. However, in some gliders and many powered aircraft, no apparent change will occur until several turns after the stick has been moved fully forward. The ailerons should always be centralized.

The corrective action takes effect as follows:

1. *Full opposite rudder*. This tends to slow the rate of spin which results in a nose-down pitching movement helping to unstall the wings. As the rate of spin is reduced, the auto-rotation is also reduced because the wings become more equally stalled. The pause is to allow the rudder a moment to take effect before taking any further action.

2. *Stick steadily forward*. This pitches the nose down and unstalls the wings. Immediately the wings become unstalled, the auto-rotation must cease, and the spin has stopped leaving the glider in a dive. The rate of spin may actually increase just before it stops and this, or any other change, are signs that the spin is stopping. The speed up in the rate of spin is caused by the governor effect of the mass of the aircraft while it spins. When the spin steepens, the radius of the spin is reduced and the inertia in the governor effect speeds up the rotation.

3. *Centralize the rudder*. Since the spin has stopped, the rudder is no longer required. The aircraft is in a steep dive or diving turn and the controls should be used normally to bring the glider back to level flight. If necessary the air brakes should be opened fully to prevent the speed from becoming excessive.

Note that the pause after applying the full opposite rudder is not intended to be a pause until the spin stops. In some types of aircraft the spin will not stop until the stick has been moved forward to unstall the wings. In others, the spin may stop immediately the opposite rudder is applied and the rudder must be centralized promptly or a spin in the opposite direction may occur.

Care must be taken not to pull out of the dive too sharply or a high speed stall may occur and more height will be lost.

No mention has been made of any action to be taken if the glider does not seem to be recovering from a spin after the correct recovery action has been taken. Any other action may only hinder the recovery and it cannot be too strongly emphasized that on no account should the full opposite rudder be relaxed until the spin has stopped. Provided that the glider is correctly loaded and is undamaged the normal recovery action will be effective.

THE EFFECT OF THE AILERONS

The position of the ailerons can have a marked effect on the characteristics of the full spin and recovery, but it varies with the type of glider. Usually in modern machines, aileron applied in the direction of the spin (known as "in spin" aileron) increases the rate of rotation and delays the recovery slightly. "Out spin" aileron then helps to stop the spin and tends to turn it into a yawing, spiral dive. With some older designs the aileron has little effect except to help a full spin to be achieved when the full "out spin" aileron is applied.

These effects may vary slightly with different loading and the ailerons should always be centralized at the start of the spin recovery action.

It is interesting to recall the effect of aileron during the incipient spin. Then any attempt to stop the dropping wing almost always results in the wing falling further. It should also be noticed that a rapid movement of the ailerons near the stall can roll the glider so quickly that the dropping wing tip stalls in spite of that aileron being up at the time. This can easily occur during a slow winch launch if the "too slow" signal is given too enthusiastically.

INVERTED SPINS

Unintentional inverted spins on gliders are almost impossible because of their inherent stability. If the glider is stalled while it is upside down, it will fall away to one side by dropping the nose or one wing with no tendency to spin upside down. It may possibly fall into a normal spin, in which case, a normal spin recovery should be made.

CHAPTER 16

SAFE FLYING IN HIGH WINDS

Ground handling precautions—The wind gradient—Launching in high winds—The effects of turbulence near the ground—Special precautions

PILOTS who have been trained and sent solo in good conditions may often reach quite an advanced stage without ever having flown in a high wind, and they may unwittingly be sent solo in conditions which they have neither the experience nor the skill to manage safely.

Errors such as a slow approach or a low final turn and approach become more dangerous in windy and turbulent conditions.

The instructor in charge of flying is responsible for insisting that only really competent pilots fly solo when conditions are very rough. In most cases even experienced pilots can benefit from dual flying in such weather.

It is difficult to lay down any definite strength of wind which limits safe operating. However, it is seldom worth taking any risks unless soaring flights are possible. On the ground, the greatest care is needed to operate safely in winds of over 25 m.p.h. In the air, the limitation is more often set by the amount of turbulence near the ground. It may seem strange that gliding usually continues in winds which ground most other light aircraft. This is only possible with careful ground handling.

GROUND HANDLING PRECAUTIONS

If the glider is facing into a strong wind with insufficient weight on the nose, it will be blown over. This can happen very easily if the men on the tail press down so that the wing is at a large angle of attack to the wind.

Once the glider leaves the ground there is little that the ground crew can do to prevent it from blowing over backwards. This type of accident always does extensive damage, often costing several hundred pounds to repair. It can easily be avoided by ensuring that there are always plenty of people available to hold gliders down and that they are well briefed, and positioned where their weight will be most effective. The tail men in particular should be experienced glider crews. The air brakes or spoilers should be opened to reduce the lift of the wing, and the pilot's seat should be occupied all the time. Frequently, blow over accidents occur through lack of supervision when in fact there are ample people to hold the glider safely. In windy weather, an instructor or a very experienced person should take control of the crew and ensure that they all know exactly what to do. Moving forwards downwind, the wind may tend to get under the tail plane if the tail is held high and it is therefore necessary to hold the tail down in this case to prevent an accident. It is usually safer to push the glider by hand downwind rather than risk towing it behind a car as it may tend to overrun and collide with the back of the vehicle. Across wind the wing tip men have the safety of the glider in their hands, and must be particularly careful to keep the wing tip low so that the wind helps to hold the glider down instead of blowing it over. Extreme care must be taken turning the glider to ensure that the correct wing tip is held all the time. It should always be remembered that the cost and frustration of a damaged glider far outweighs the value and pleasure of flying in a very high wind. At most clubs the risks are assessed by the C.F.I. or instructor in charge who makes the decision to carry on or cease flying. It is very easy for him to put off the decision until conditions become dangerous for taking the gliders back to the hangars.

He is always right in stopping flying before an accident happens and always to blame if an accident occurs when flying continues in bad weather.

Since fairly strong winds are required for satisfactory hill soaring conditions, flying at hill sites is carried out in any weather in which the gliders can be safely handled on the ground and launched. The trainee at such places usually receives plenty of experience in windy conditions and soon becomes used to flying in the turbulent air near the hill side.

On flat sites situated in open country, severe conditions may be extremely rare and this may result in fairly experienced pilots being unable to fly safely in really rough conditions.

WIND GRADIENT

The "wind gradient" is the change in wind speed with height and is caused by the slowing down of the lower layers of the air as they pass over the ground. The "wind gradient" is said to be steep or pronounced when the change in wind speed with height is very rapid and it is in these conditions that extra care must be used when taking off or landing in a glider.

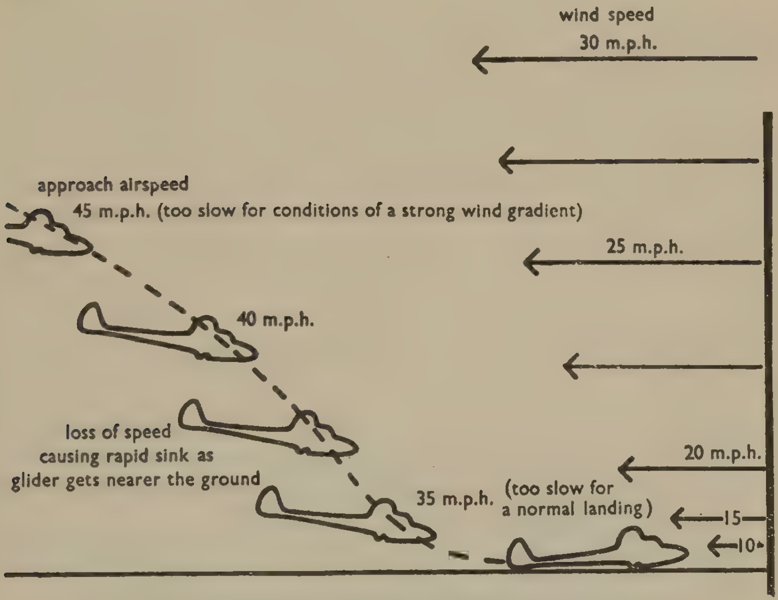


Fig. 38. The effect of the wind gradient during the approach.

Fig. 38 shows an example of a "wind gradient". The friction of the ground reduces the wind speed near the surface just as skin friction reduces the speed of the lower layers of the airflow over an aerofoil. If the surface is very rough, the friction will be greater and the lower layer will be slowed to a greater extent. This occurs when the area upwind is rough or covered with trees or houses.

The steepest "wind gradient" is to be expected in high winds and to the leeward of rough ground. In these conditions, precautions must be taken to minimize its effects. It will be seen that the change in wind speed is very pronounced near the ground and up to 100–200 feet and then becomes less, until at about 1,000 feet it is negligible.

In light winds, the wind gradient effect will be too small to affect a glider landing.

A glider coming in to land takes only a few seconds to lose the last 100 feet or so of height. When there is a steep "wind gradient" this means changing quickly from flying against a strong wind to flying against a much lighter wind. The glider, however, has considerable inertia and tries to maintain its original speed over the ground so that the reduction in wind speed causes a sudden drop in airspeed. In extreme cases the glider may even become fully stalled as a result of this sudden drop in airspeed.

The reduction in airspeed will cause the glider to sink rapidly and this effect is accumulative as height is lost. Finally, when the glider gets near the ground, since it is almost stalled it will need almost the full movement on the controls to level off for landing. In most cases a situation like this results in, at best, a heavy landing. Unfortunately the instinctive reaction to finding the glider sinking rapidly during the approach is to try to check the descent by easing back on the stick. This will only reduce the airspeed further and so increase the risk of stalling and in any case will result in a higher rate of sink after a few seconds delay.

It should be noticed that this is an occasion when the stall can occur with the glider in the normal gliding attitude. It is not necessary to have the nose high as in most cases of the stall, as the rapid sink of the glider increases the angle of attack of the wing.

The correct action during the approach through a steep "wind gradient" is to come in at speed well above normal (at least cruising speed plus 15 m.p.h.) and to lower the nose to maintain this speed as the last 100 feet of height is lost. This will ensure that, when it is time to level out for landing, there is plenty of speed in hand so that normal control is available to correct for any gusts near the ground.

Alternatively, if the approach is made a little faster, a constant attitude can be held which will result in a normal approach speed being reached by the time the glider is near the ground.

In conditions of high wind and gustiness near the ground, it is advisable for an inexperienced pilot to restrict the air brake setting to about half for the last 20–30 feet of the approach and landing. Any tendency to level off the glide too high or to balloon up because of a gust will result in a rapid loss of speed. This effect, together with the drop in speed caused by the "wind gradient" as the glider sinks on to the ground may end in a heavy landing. A reduced amount of air brake allows the pilot more time to correct any faults and is, therefore, a wise practice for inexperienced pilots. If a bad approach or landing is made in these conditions, the pilot's first action should be to move the brakes in to allow himself more time to control the situation.

The rapid sinking of the glider on the final approach in windy weather is often wrongly assumed to be the result of a down-draught or area of sinking air. In fact, this effect can be found anywhere when approaching to land in a strong "wind gradient". If the approach is badly judged so that there is a tendency to undershoot, any attempt to stretch the glide or check this sinking by holding up the nose will result in a more serious undershoot and possibly a fully stalled approach. This is the most dangerous action the pilot can take, particularly in a high wind.

LAUNCHING

The initial part of the launch is also in the steepest part of the "wind gradient" and this results in a very rapid increase in speed as the glider gains height. The winch or car driver compensates for this by throttling back as the glider begins to gain height.

In order to prevent the winch engine stalling at the low speed needed in high winds, it is usually necessary to launch in a low gear. The take off may then require full power to reach a safe speed because the wind speed on the ground is much less than its speed at height. Frequently in these conditions, the initial launching speed tends to be slow and, for this reason, particular care is needed. If the winch fails or the cable breaks during the climb to a safe height and while the speed is low, a very critical situation arises. The slightest delay in lowering the nose will result in a stall, and even if this is recognized as such and the nose is lowered farther to regain speed, the rapid loss of height through the wind gradient prevents a quick recovery and may result in the stall becoming more complete.

Recovery from a semi-stalled situation below 150–200 feet in these conditions takes an abnormal amount of height, and only very prompt and deliberate action can prevent doing serious damage to the glider. (Fig. 39.) It is particularly vital that the air brakes are left alone until normal approach speed is obtained if the cable breaks during the first part of the climb. If the glider is already almost

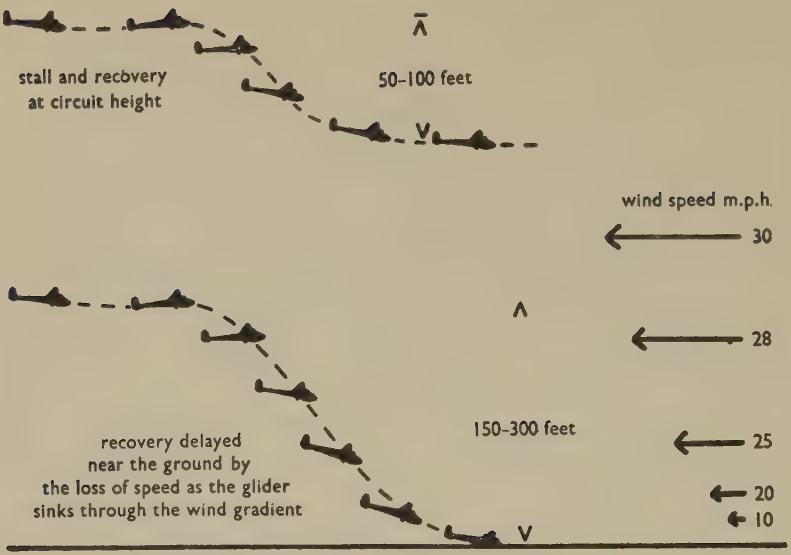

stall and recovery at circuit height
50–100 feet
wind speed m.p.h.
30
28
25
20
10
150–300 feet
recovery delayed near the ground by the loss of speed as the glider sinks through the wind gradient

Fig. 39. The effect of the wind gradient on the recovery from a stall near the ground

stalled, the high drag and loss of lift occurring when the air brakes are opened may stall it.

TURBULENCE

The severity of turbulence in the air depends on several factors. The most vicious turbulence will generally occur in conditions when the air is unstable and the wind strength high. Obstructions such as hills, trees or buildings will all help to break up smooth airflow and cause difficult and even dangerous conditions for the glider pilot.

In very turbulent air, gusts in all directions of 10–20 m.p.h. are quite common. These can stall the glider or roll it over out of control into a steeply banked attitude particularly if it is flying too slowly at the time. Most gliders have a comparatively poor rate of roll and, if they are turning near the ground when they are rolled over, there may not be time to bring the wings level before the glider strikes the ground. This is a very real hazard and many "know all" pilots have learnt the hard way the dangers of turning near the ground. Many others continue this bad habit and set a bad example to more junior pilots giving them the idea that it is rather clever to fly like this. In fact, of course, it shows poor judgement in planning the approach.

Turbulence can often be avoided by by-passing the likely areas caused by surface obstructions and irregularities. The area in the lee of a hill is usually one in which severe turbulence will be found in windy conditions. The "wind gradient" is usually abnormally steep because in some places the surface wind may even be reversed near the ground just behind the crest of the hill and the air may be very violent for several miles downwind.

Areas in the lee of trees or other obstructions will also be particularly turbulent up to a height of several hundred feet and should be avoided whenever possible for approaches and landings. As a matter of principle, approaches should never be made over obstructions if there is an alternative clear approach which can be used.

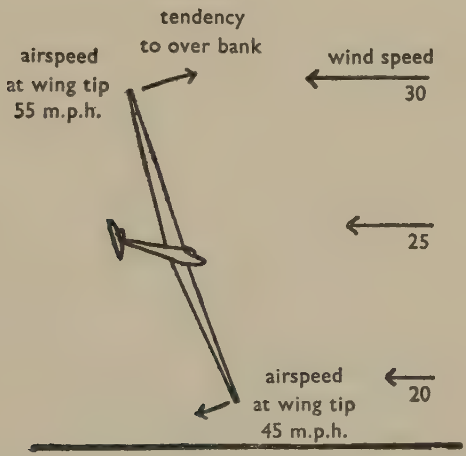


Fig. 40. The dangers of turning near the ground in a high wind.

Experience shows that maintaining a reasonably high speed will not necessarily prevent loss of control in turbulence. Frequently when gliding in high winds, the glider is rolled over by a gust against the use of full aileron and rudder even though flying at twice the normal stalling speed. In straight flight the risks of losing a critical amount of height in this kind of situation are not great. If the glider is already banked, it may be rolled right over and 100 feet or more may be lost recovering to level flight. Near the ground, recovery from a steep bank in a glider is abnormally poor because the lower wing may be as much as 40 feet below the other wing tip. The lower wing is then in a much lighter wind than the other and has, therefore, a much lower airspeed and less lift. This difference helps to steepen the bank and reduces the effectiveness of the ailerons when they are used to attempt to bring the wings level. (Fig. 40.)

The wise glider pilot will always approach from a much greater height in windy conditions; he avoids obviously turbulent areas whenever possible and approaches with plenty of speed to combat the effects of the "wind gradient". This does not entail excessive retrieves because in any case the glider makes little progress against a strong wind.

The approach may be upset by strong rising or sinking air unless a safety margin is allowed for them all the time. At times the rate of descent may reach 15–20 feet per second in these down-draughts so that 200 or 300 feet may be lost in the time it takes to turn and make towards the nearest landing area into wind. In such conditions, it is always necessary to fly in a position from which a safe landing can be made even if 200 or 300 feet are lost without warning.

SPECIAL PRECAUTIONS

The effect of the wind on the track and ground speed of the glider is very much more marked in strong winds, and can lead the unwary into difficult situations. Flying downwind, the ground speed is often doubled and this necessitates commencing a turn across wind long before it is normally necessary if the glider is not to be taken beyond the downwind boundary during the turn with little hope of regaining the airfield.

The inexperienced pilot may also be tempted to try and reduce the ground speed by raising the nose and this will result in stalling the glider. This is particularly easy to do in heavy rain, when the noise of the airflow and rain may give the impression of normal flying speed when in fact the glider is almost stalled. The gliding angle in relation to the ground will be much flatter flying down wind and this may upset the judgement on the circuit. Across the wind the glider will drift at a considerable angle and once again the inexperienced pilot may try to eliminate this sideways movement by applying rudder. This misuse of the rudder by skidding the glider will result in additional drag, loss of speed and hence possibly the conditions for a spin. The effect of the wind makes it particularly dangerous to make a 360 deg turn anywhere near the downwind boundary as it results in the glider being drifted over the boundary.

Into wind, the glider will make little progress at normal flying speeds so that, if the approach is started from behind the boundary, it may easily end by a landing on the fence. A sound rule is not to go behind the boundary when the wind is very strong and this is almost universal practice. Unfortunately, an error of judgement or a moment of carelessness can easily result in finding oneself behind the boundary in a difficult situation. What glider pilot sooner or later does not find himself in this predicament? You must try to avoid it and know exactly what is the best action to take if it does occur.

The instinctive reaction to undershooting is to try to stretch the glide by raising the nose. This is the wrong thing to do at any time but is fatal in windy conditions because a reduction in speed reduces the ground speed still further and so results in losing height without so much forward progress. Also, of course, this will give the "wind gradient" the chance it is waiting for to stall the glider.

If there appears any chance of undershooting, the nose should be lowered well below the normal attitude to gain speed as rapidly as possible. Although this will result in a rapid loss of height, the glider will then penetrate against the head wind. A further advantage is that the glider arrives close to the ground at high speed where the wind is lighter and considerable distance will be covered floating with the excess speed. It is interesting to consider the speeds and angles of glide against strong winds in order to decide upon a sound policy for situations like this.

The examples shown in Fig. 41 show diagrammatically the effects of flying at various speeds into a head wind of 30 m.p.h. in two well-known types of gliders. Very similar results occur with all but the most primitive gliders such as open primary types.

It will be noted that the penetration against a strong wind improves with an increase in speed and remains good up to speeds which are at first sight impracticably high. At low speed, penetration is very poor besides there being little or no excess speed with which to float during the hold-off period.

The best speed for penetration can be found by the simple rule of thumb method of adding one-third wind speed to the speed for best

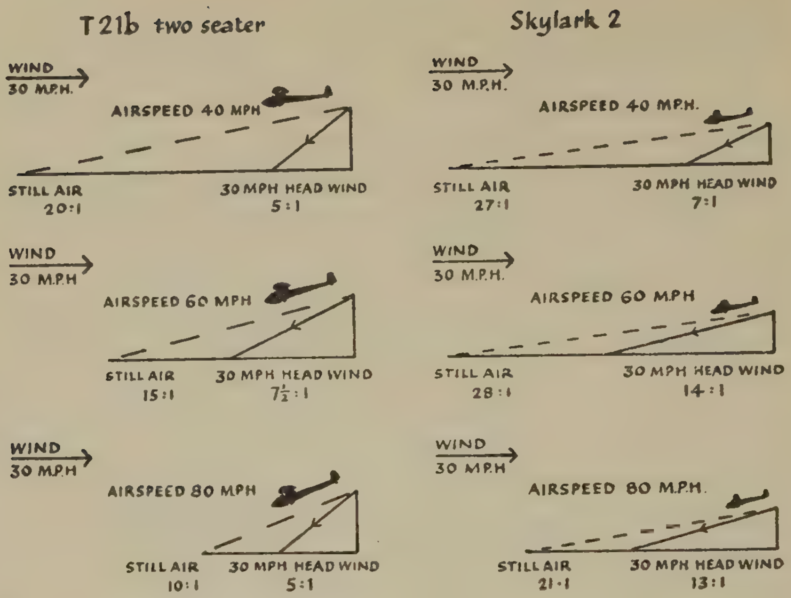


Fig. 41. The effects of flying at various speeds against a strong wind. Solid lines show the glide path against a 30 m.p.h. wind, to which must be added the distance which the glider floats before landing. This will be considerable with higher approach speeds as the wind speed is much lighter near the ground.

gliding angle in still air. This simple method gives very accurate results for most types of gliders, and is a suitable minimum speed for normal approaches in windy conditions. If the glider has been allowed to get into a critical situation, there must be no mistake. It is better to fly even faster than the theoretical speed for penetration. This will result in very little loss and will minimize the effects of any turbulence or down-draughts encountered. The examples given show that the penetration does not suffer seriously until the speed is well above the ideal. The moral is clear: if in doubt fly faster.

There will be no second chance if the speed is too low because an undershoot is then inevitable.

The speed for best penetration should also be used in flight at any time when it is essential to make progress against the wind in spite of losing height. For example, on some sites the ridge is well upwind of the launching point and it is necessary to penetrate against the wind to reach the ridge. Here the best speed will be that for best penetration, or slightly above that if it is considered likely that the glider will be flying in the down current or turbulence behind the hill top.

CONCLUSIONS

1. Special care must be taken all the time when handling the glider on the ground in high winds. Allow six people for each glider and ensure that they are well briefed and under the control of one person.
2. If the conditions are deteriorating, stop flying long before handling on the ground becomes dangerous. Gliding in very turbulent high winds is risky.
3. Do not fly far beyond the downwind boundary in windy conditions.
4. Be prepared for the effects of "wind gradient" near the ground. The initial climb must be gradual and immediate action taken to regain speed for the approach if the cable breaks. The approach speed must be adequate—if in doubt, approach too fast rather than too slow. Avoid turns near the ground.
5. Avoid approaching over obstructions or landing in the turbulent area in the lee of them.
6. Always initiate the turn from the down-wind leg of the circuit on to the last crosswind leg much earlier than normally to ensure that the glider does not get blown down wind of obstructions in the turn.
7. Flying down wind ignore the high ground speed and ensure that a safe AIRSPEED is maintained. In rain, hail or snow beware of the apparent speed caused by the appearance and noise of it. (Rain may make the A.S.I. read incorrectly.)
8. If the glider is allowed to drift too far down wind in windy conditions lower the nose and gain extra speed for penetrating. Too much speed is better than too little. Land short of the landing area rather than stall on to the boundary.

   Above all, fly within easy reach of a safe landing area allowing for a possible loss of height of several hundred feet at any time.

CHAPTER 17

LAUNCHING BY AEROTOW

The advantages and disadvantages of aerotowing—The towing aircraft and equipment needed—Points for inexperienced tug and glider pilots—The take off—The normal and low tow positions—Turns—Releasing the tow rope—Crosswind take offs—Emergencies—Twin towing

THE advantage of the aerotow lies in its flexibility. The glider can be launched to almost any height and can be towed into a thermal or to a particular place before releasing. This is a great advantage on days with poor conditions when a series of winch launches to 1,000 feet would not have much likelihood of reaching lift.

If a launch height of 1,000–1,500 feet is required, a winch or autotow launch is quicker and cheaper.

The aerotow is one of the simplest forms of launching in smooth conditions as the pilot has only to maintain a steady position in relation to the tug. Most pilots should be capable of flying the glider on aerotow after about twenty solo winch or motor-car launches, or five to ten hours' gliding. If glider training is carried out solely by aerotow, the average pupil pilot should be handling the glider unaided for most of the aerotow after five or six launches. Aerotowing in smooth conditions is a very different matter to aerotowing in the turbulent conditions on soaring days.

The take off and initial climb of the tug and glider combination is comparatively poor in most cases and the effect of strong turbulence such as the curl over effect behind a hill may prevent the combination climbing.

Another factor which must be considered is the result of an engine failure or premature release just after take off. If the site is surrounded by wooded or rough ground the chances of a successful landing by either the tug or glider are slight unless some hundreds of feet are available for selecting and reaching a suitable landing area.

Weighing up the considerations for and against this kind of launch, it clearly depends upon the suitability of the site and the type of towing aircraft available. The initial cost of the launch is high because of the fuel consumption and upkeep of the aircraft, but the prospects for soaring are greatly improved. This makes aerotow launching well worth while for advanced soaring flights, from flat sites.

THE TOWING AIRCRAFT AND EQUIPMENT

In Great Britain, powered aircraft have to be specially cleared by the Air Registration Board for aerotowing. They ensure that the rate of climb is sufficient to enable safe towing to be carried out and lay down the limitations of load in the tug and the maximum weight of the glider which may be towed. The low maximum towing speeds of most gliders make engine cooling a special problem on most towing aircraft. There is a serious tendency to overheat, particularly at full power. Ideally the tug should be able to tow comfortably at a speed of at least 5–10 m.p.h. below the maximum permitted towing speed for the glider.

The release hook is generally mounted on or near the tail skid of the tug with a cable release operated from the cockpit. It is not fitted with an automatic override, in order to ensure that there is no possibility of the rope releasing itself if the glider gets out of position.

A mirror should be fitted in the cockpit so that the tug pilot can see the glider without having to turn round. A glider type variometer is another useful addition to the tug. This will help the tug pilot to find and climb in the thermals and will often reduce considerably the time taken to climb.

The towing rope is usually nylon but can be any suitable length of hemp or manila rope. A nylon rope need only be about one-third of the diameter of the equivalent hemp one and gives a very smooth tow as it stretches under load, reducing the shocks of sudden jerks. A weak link should be incorporated at the tug end if the breaking strain of the rope is more than permitted by the placard in the glider or tug.

The ideal length for the rope seems to be 150–200 feet although a skilled pilot can manage without difficulty with less than 100 feet. A short rope increases the possible take-off run of the tug, which is a definite advantage when flying from small fields.

Launching cable or wire should not be used for aerotowing, as it will cause serious damage to the glider if it breaks and is blown back over it. It also has very little give in it, so that the glider and tug may be badly jerked during gusty conditions.

If two releases are fitted to the glider the nose release should be used for aerotowing. The automatic override of this release should be made inoperative unless a nylon rope is being used. A simple method of doing this with the Ottfur type of release is by taping round it with three turns of insulating tape or locking wire. Unless this precaution is taken a heavy rope may release itself if it becomes slack in rough conditions.

If the glider has an open cockpit, a pair of windshields or goggles are needed since the glider tends to assume a nose-down flying attitude on tow, so that the windscreens offer very little protection from the 50–60 m.p.h. airflow.

BRIEFING

If either the glider pilot or the tug pilot is inexperienced, it is vital to have a talk before the flight to discuss the signals, etc, to be used. Ideally the tug pilot should also be a glider pilot. This should enable him to find strong lift to improve the rate of climb and so save fuel. However, should the tug pilot be new to the job it is important to make sure that he understands the following points:

1. The maximum towing speed of the glider.
2. The need for full power for take off and the initial climb and the need for turns to be gentle.
3. The need to check that the glider has its air brakes closed before take off and after starting to climb, and at any time if the tug does not seem to be climbing normally.
4. Where to climb, i.e. up wind of the field but within gliding range, unless otherwise stated, and the height required.
5. Whether it is intended to fly in the high or low tow position. (He should be ready for the change of trim and not assume that the glider has released if the tug suddenly starts to accelerate; this may be the glider changing position or jerking the rope.)

6. The signals to be used to indicate that the glider must release, and that the glider is unable to release.
7. That he must not enter cloud.
8. Where to drop the rope.
9. The need to approach at least 200 feet above any obstruction when approaching the field to release the rope.

The glider pilot must also be carefully briefed if he has never done an aerotow launch before.

In the past it has been the usual practice to make initial aerotows solo and there have been remarkably few incidents. However, it is much better to be able to carry out at least one dual tow during which any difficulties can be eliminated. If it is necessary to start solo, the conditions should be smooth and an experienced pilot must be flying the tug aircraft.

THE TAKE OFF

Since the distance between glider and tug is short, the signals can safely be given by the wing tip orderly or pilot to a signaller standing about twenty yards ahead and to the left of the tug, in a position clearly visible to the tug pilot.

The tug is taxied forward slowly to take up the slack in the rope until the signal "All Out" is given.

If the glider is fitted with a wheel, the pilot should get the weight off the front skid as quickly as possible in order to reduce the ground friction to a minimum. In any case, the glider should be lifted off the ground as soon as possible and then flown at a height of 5–10 feet to allow the tug to accelerate quickly to take-off speed. Full power should always be used for take off and the tug pilot should lift the aircraft off the ground without delay once a safe speed has been reached, and start to climb without delay. If the glider flies too high on take off, the tug pilot will need a firm backward movement on the stick to leave the ground.

Since the towing speed is well above the normal cruising speed of the glider, it is necessary to increase the forward pressure on the stick gradually to hold the glider in position as it gains speed.

Unless an elevator trimmer is fitted, this pressure must be continued all the time or the glider will climb too high. Provided that the glider is kept directly behind the tug there should be no difficulty in holding position as the tug begins to climb. It is vital to prevent the glider flying too high during the take off or initial climb as this will pull the tail of the tug up and prevent it leaving the ground. If this happens, the tug pilot is quite justified in jettisoning the glider. The trimmer should always be set forward for take off.

If the field is short, a slight advantage may be gained by moving down into the low tow position as the tug is just leaving the ground. This reduces the load on the tug for a few seconds as the glider dives down. Alternatively, the glider may be held down very near the ground all the time until the tug has taken off and climbed up to a correct position for the low tow position.

Both of these methods, together with the use of a short tow rope should only be used by experienced pilots when the length of run available is critical. When considering the conditions for take off the following factors should be borne in mind: the experience of the pilots, the weight and drag of the glider, power of the tug, wind strength, take-off run, slope of ground and possible down-draughts.

If the tug seems unable to climb, the cause is almost certain to be that the air brakes have opened. Always recheck the air brakes if the launch looks or feels abnormal.

The glider pilot must always be prepared to abandon the tow if there appears to be any risk of the tug not being able to clear the far boundary. This decision must be made in plenty of time so that there is room for a safe landing. The glider pilot should always be able to anticipate the tug pilot jettisoning the glider and should cast off at any time when the tug appears to be in a difficult situation. It may be difficult for the tug pilot to operate the release and control his aircraft at the same time.

THE NORMAL TOW POSITION

The correct position is with the glider flying just above the level of the slipstream of the tug aircraft. This is the normal position assumed after take off. The easiest way of judging this position is by the view of the tug as seen from the glider. Normal and low tow positions are shown for various tugs in Fig. 42.

For the better tugs (Pawnee, Super Cub, etc.), the normal tow position is with the tow plane just above the horizon. The ideal position is about 10–20 feet above the top of the slipstream as this allows for getting out of position in turbulent conditions without running into difficulties. Actually, the slipstream can be felt, heard and smelt if the glider is allowed to descend into it. Unless the glider is accurately lined up behind the tug, the slipstream may tip the glider as one wing gets into it and it may be difficult to correct this unless the glider is pulled up out of the slipstream first of all.

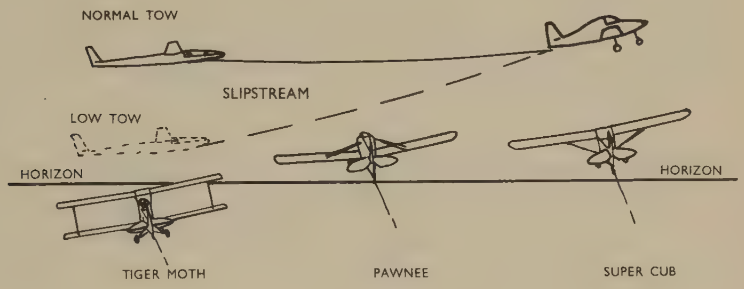


Fig. 42 The normal tow position. Note much higher position of fast climbing tugs.

Care must be taken not to let the glider get too high or the tail of the tug will be pulled up putting it into a dive. Within a few moments the speed will build up so that, unless prompt action is taken, this situation may become worse and it may be necessary for the glider pilot to release.

In smooth conditions a satisfactory tow will result if the glider pilot maintains the correct position accurately. This requires the undivided attention of the glider pilot and it is, therefore, essential that he is completely prepared for the flight before take off. No attempt should be made to look at maps or make notes during the tow as a few seconds distraction can result in the glider getting right out of position and may mean having to abandon the launch. The pilot must concentrate on holding the correct position, and any corrections should be made as gently as possible. At the comparatively high speeds on tow, the glider controls are heavier than in normal flight and the elevators in particular are usually very sensitive so that care must be taken in adjusting height. The movement of the tug gives a very good indication of the presence of a thermal since the tug flies into it first and is lifted before the glider. Smooth corrections are needed if any change in position occurs during the tow. The general tendency is for the glider to get too high because any relaxation on the controls will result in it climbing.

If it does, the nose must be lowered very gradually or the glider will gain speed, allowing the rope to get slack. A few seconds later, as the glider slows down and the tug accelerates without the drag of the glider, the rope will snatch tight giving both the tug and glider a severe jerk which may break the towing rope. If a nylon rope is being used, it will stretch and then catapult the glider forward again. The extra speed makes the glider climb up and slackens off the rope

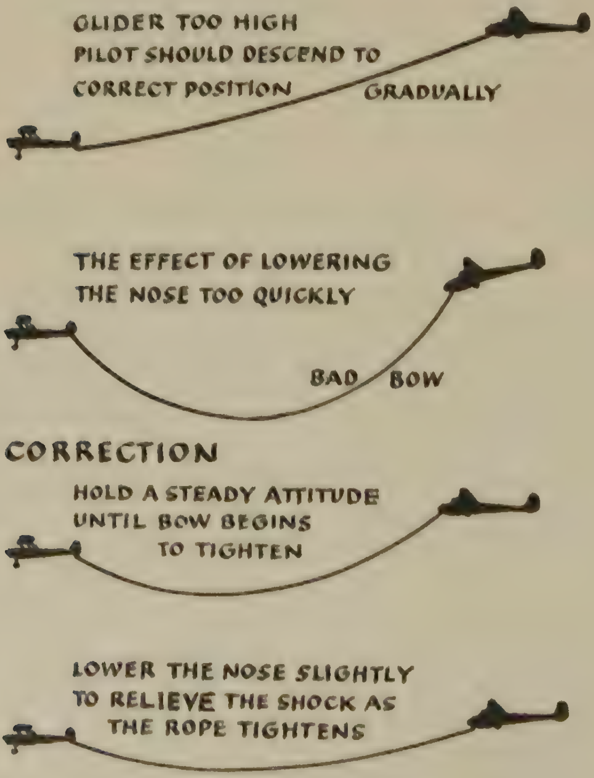


Fig. 43. Correcting bad bows in the tow rope.

so that once this surging starts, prompt action is needed to prevent it developing further and causing a break. If the "bow" in the rope is only a slight one, no action need be taken other than to hold the correct towing position as the slack comes tight. However, if the "bow" is serious, the glider should be held in position until the rope begins to tighten up. The jerk can then be eliminated by lowering the nose slightly just before the rope comes tight. This increases the speed of the glider for long enough to prevent the jerk. When a correction is made in this way, it may result in the glider getting into the slipstream for a few moments but this is of far less importance than the risk of breaking the rope. (Fig. 43.)

If a very bad "bow" is allowed to develop, it is probably better to release than to endeavour to damp it out. Excess height in relation to the tug can be lost without gaining speed by making the change very gradually. The air brakes should not be used unless it is absolutely necessary as they cause so much drag that the combination may be unable to climb. Excessive use of the air brakes has been the cause of several forced landings in the past and it is unnecessary to use them except on the rare occasions when a descent is made on tow.

The normal tow gives a good view of the ground ahead so that the pilot can see suitable landing fields just after take off, when a forced landing requires immediate action to get down safely. It is also much better when flying towards the glare of the sun as the pilot is looking down on the tug and rope and can see them clearly all the time.

THE LOW TOW POSITION

The low tow position is with the glider flying just below the slipstream of the tug. Before going down to the low tow position the glider should be lined up directly behind the tug in order to pass straight through the rough air of the slipstream until it arrives in the smooth air below in approximately the position shown in Fig. 42. If this is done smoothly no "bow" will form in the tow rope. The correct position is easily determined by moving up very slowly until the buffeting of the slipstream is felt on the wing or canopy above the pilot. Having found the edge of the slipstream, the ideal position a few feet below the slipstream can be assumed. In the low tow position care must be taken not to get too low or the tail of the tug will be pulled down causing it to stall. The glider pilot must concentrate on holding the correct position and, if necessary, eliminating any bows in the towing rope.

The low tow position is less tiring to hold for long flights as the tug and rope can be more easily seen against the sky (except when flying towards the sun). It is easier to make corrections without getting the tow rope slack and the tendency to get a little too high does not upset the tug. It has also been suggested that the rate of climb is slightly better with the glider in the low tow position. The only disadvantage seems to be the risk of damaging the glider should the rope break over it and, for this reason the high tow position should be resumed if there is any likelihood of this happening.

TURNS

With an inexperienced glider pilot the tug should not exceed a gently banked turn except in emergency since it will make it difficult for the glider pilot to hold position. However, it is possible to tow in steeper turns (up to rate 2 indicated in the tug) and this may enable the tug pilot to make use of thermals to improve the rate of climb and save the need for full power all the time. No signals are given between the tug and glider during the tow so that the glider pilot must watch the tug all the time. The first indication of a turn is the aircraft beginning to bank, and the glider should begin to bank immediately so that it follows the tug round with the rope meeting the

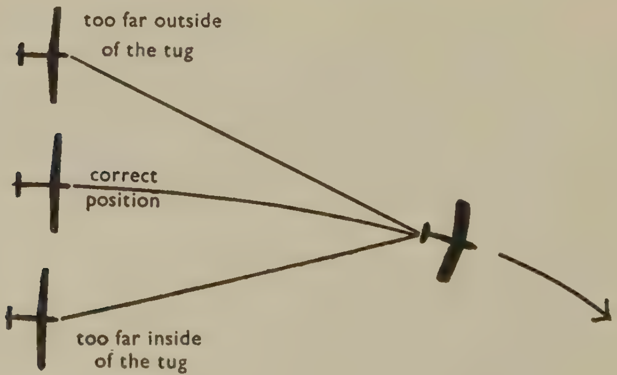


Fig. 44. Turning on aerotow.

nose of the glider in line with its fuselage. An accurate turn should hold this position, and either the high or low tow position will keep the glider out of the slipstream. Steep turns in the normal position necessitate moving a little higher in order to keep above the slipstream. Unless rising air is being exploited to assist the climb, only gentle turns should be made since any turn seriously reduces the rate of climb. If the towing rope is at an angle to the nose, the glider is not in line with the correct path of the turn. (Fig. 44.) This often occurs during a prolonged turn when, without realizing it, the glider pilot may easily apply rudder so that the turn becomes inaccurate and difficult to maintain smoothly. It sometimes helps to remove the feet from the rudder pedals for a moment to relax them and to get back into position by gentle use of the ailerons. Sometimes, through a combination of circumstances, the glider may get into the slipstream which can cause a temporary loss of control. If the glider will not respond to the ailerons it can be assumed that this has happened. It should be pulled up out of the slipstream firmly and then control will be regained immediately.

RELEASING THE TOW ROPE

If the glider has been towed upwind of the gliding site, the decision to release can be made by the glider pilot at any time, or the tug pilot may be briefed to waggle his wings when he wants the glider to drop off. In this way an experienced tug pilot can wave off the glider in an area of lift so that there is little chance of it not soaring. The glider pilot should always release from the normal tow position and should turn off immediately into a climbing turn so that he is clearly seen by the tug pilot who can then throttle back and dive back to the airfield. After the tow, the glider pilot may find himself flying too fast. This can be avoided by retrimming and bringing the glider near to the stall for a few moments after release. Unless a barograph is carried in the towing aircraft as well as the glider, the glider should lose height for at least 200 feet and hold that height for long enough for the barograph to record a short step before beginning to gain height. If the glider is already in lift, circling down with full air brake may enable this to be done without losing the lift. The launch height will then be taken as the highest point on the step. The tug pilot must note the time, height, and position of the release for record attempts.

If a barograph is carried in the tug, the rapid dive after casting off will mark the time and height of release and there is no need for the glider pilot to dive down after release. A comparison between the tug and glider barographs enables the launch point to be determined clearly.

Once the glider has released the rope, the towing aircraft can lose height ready to drop it before landing. Care must be taken not to approach low over the boundaries of the field or over the top of any gliders on the ground as the rope dangles below the tug. The release should be operated several times and if there is any doubt about it the pilot should watch for a signal from the ground to indicate that the rope has in fact dropped, before landing. If there is any doubt about the rope releasing, the tug should approach high over obstructions and land well into the field, keeping the release pulled if there is any chance of the rope catching on objects on the field.

CROSSWIND TAKE OFFS

Slow acceleration on take off can lead to difficulties in a crosswind. If the glider has the main wheel ahead of the centre of gravity, the tendency to weathercock into wind may be very marked and beyond the control of the rudder. By starting with the glider slightly on the upwind side of the tug, the tow rope loads will help to keep the glider and tow plane straight. Full rudder should always be used and the upwind wing tip must be kept low. A slight swing may still occur but can be corrected as the tug gains speed.

EMERGENCIES

In the event of the glider being unable to release the towing rope, the glider should be flown out to the left of the tug about one span distance in order to attract the attention of the tug pilot and then the wings should be rocked. The tug should then tow the glider over the field and release the rope from the tug end. From here the glider can make a high approach to ensure that the end of the rope does not catch in anything on the boundary. If the speed is kept above normal and the release is kept pulled, the rope should pull out of the release if it catches on anything during the landing.

In the event of the tug pilot wishing the glider to release in an emergency, the tug should rock his wings vigorously. The glider pilot must release immediately; if he does not the tug pilot will invariably jettison him. The usual causes for waving the glider off in emergency are the glider taking off with the air brakes open, or engine trouble in the tug.

If the glider is towed into cloud or very poor visibility for more than a few seconds so that the pilot loses sight of the tug, the glider will have to release since it is impossible to fly for long without getting badly out of position. Heavy rain or hail, particularly in an open glider, may make it impossible to see the tug and a considerate tug pilot will keep clear of conditions which make it difficult for the glider pilot.

Care must be taken not to drop the rope, or part of it, in event of a break, anywhere except on open fields, as it might cause damage or injury besides resulting in the loss of the rope, which could otherwise have been spliced together and used again. Aerotow rope must never be knotted as any knot weakens it considerably. If the rope becomes knotted or broken it must be cut and spliced correctly.

TWIN TOWING

Twin towing is useful for cross-country tows with experienced pilots. The take-off run is much longer and *must* be directly into wind. One rope should be at least 75 feet longer than the other.

The gliders hold their position either side of the tug with rudder and a little bank. Any turns after take-off should be gentle or the inner glider may lose speed and become stalled. At a safe height the glider on the long rope goes into the low tow and they can take up a position almost in line, one above the other. The glider on the short rope releases first and pulls up and to the side he took off on. The other glider can then move up to the normal position for release.

CHAPTER 18

LOCAL SOARING AND EFFICIENT CRUISING

Useful things to practise—Short triangular flights—The gliding angle and the lift/drag ratio—Rates of descent and the effect of an increase in weight—How to use the performance curve for a glider—The best speeds to fly in various circumstances and how to find them—Trimming—Aerobatics

No gliding club can allow its gliders to be damaged or even hazarded by careless or irresponsible flying. For this reason, an unauthorized cross-country flight or a landing away from the site is treated as a serious demeanour and disciplinary action is usually taken against the pilot.

Unfortunately, many glider pilots become anxious to start cross-country flying as soon as they have made one or two soaring flights. Often they do not appreciate the subtleties of thermal soaring and fail to realize that their soaring flights were probably only made because of the exceptionally easy conditions at the time. Most pilots do not have the necessary background of experience needed for safe cross-country flying in this country until they have completed at least one season of local soaring. This period of gaining experience can be used to prepare for the future or, as often happens, it may be wasted so that the pilot is still not proficient for the following season. Only a few pilots make any real attempt to develop their skill and technique at thermal soaring systematically at this stage. It is those few who are most likely to become the outstanding pilots for the future.

A map should always be carried and used when it is possible to soar a few miles from the site. Map reading is not difficult, but it does require practice. Unless there is a headwind, a modern glider will glide about four miles for every 1,000 feet of height lost. (Olympia, Skylark, etc.) This means that on a good soaring day, a glider at 4,000 feet can safely explore the countryside within a radius of 10 miles of the gliding site and still be within easy reach of the field at any time. At first the pilot should learn to recognize the nearest landmarks to the site. Then gradually he should extend his range until eventually he is able to find his way back by estimating and then flying the compass course which will bring him back to the field, even when it is out of sight or concealed by cloud shadows. It is essential to gain experience at steering a compass course and turning on to course quickly, as the compass is a particularly difficult and obstinate instrument to use.

Local soaring means keeping within easy gliding distance of the site at all times. There must be no question of landing "away" because of an error of judgement or becoming lost. However, the pilot should practise selecting suitable fields for a landing, and should try to identify the various types of crops and the surface and size of the fields. These can often be verified by going to have a look at some of the fields on foot. In particular, the pilot should train himself to notice any slope in the ground or bad features of a particular field at a glance.

On a really good soaring day, the pilot may find that it is so easy to stay up that there seems little to be gained by carrying on. These are occasions when it is interesting to see exactly how long it takes to climb to a certain height, for example, 3,000 feet, and descend quickly to 1,500 feet again to look for another thermal. A pilot who can descend to this height and be reasonably confident of finding another thermal should have a fair chance of staying up when the time comes for him to fly across country. Trials of this kind are exciting and of far greater instructional value than many hours of thermal soaring at 3,000 or 4,000 feet where the thermals extend over a very wide area.

Many of my most exhilarating flights have been of this nature and I recall one flight in particular, early in the spring. This flight was made with the intention of flying the glider to the hangar as many club members apparently considered that the soaring conditions were beginning to fade out. I was launched by tow car in an Olympia at about five-thirty and was soon climbing rapidly in a strong thermal. At just over 5,000 feet I flew into the small wispy cumulus cloud which seemed to be capping the haze layer which marked the inversion level. After a few moments practice flying on the turn and slip indicator in the cloud, I decided to practice aerobatics on the way down. A series of almost continuous loops, chandelles and spins followed by a circuit with the air brakes open concluded the flight which had lasted just twenty minutes from take off to touch down.

It takes considerable practice to be able to fly accurately while thermalling, map reading and looking at fields. When this can be done without getting too tired the pilot should be ready to start cloud flying. For solo attempts the visibility must be good and the wind strength light so that there is no difficulty in finding the gliding site again after leaving the cloud. A windy day with large clouds and poor visibility is not suitable for first attempts at cloud flying. It is essential for the pilot to know the district over which he is flying and to note the wind direction and his exact position before going into the cloud. There is no excuse for becoming hopelessly lost and landing away after just a few minutes in cloud, but this is surprisingly easy to do.

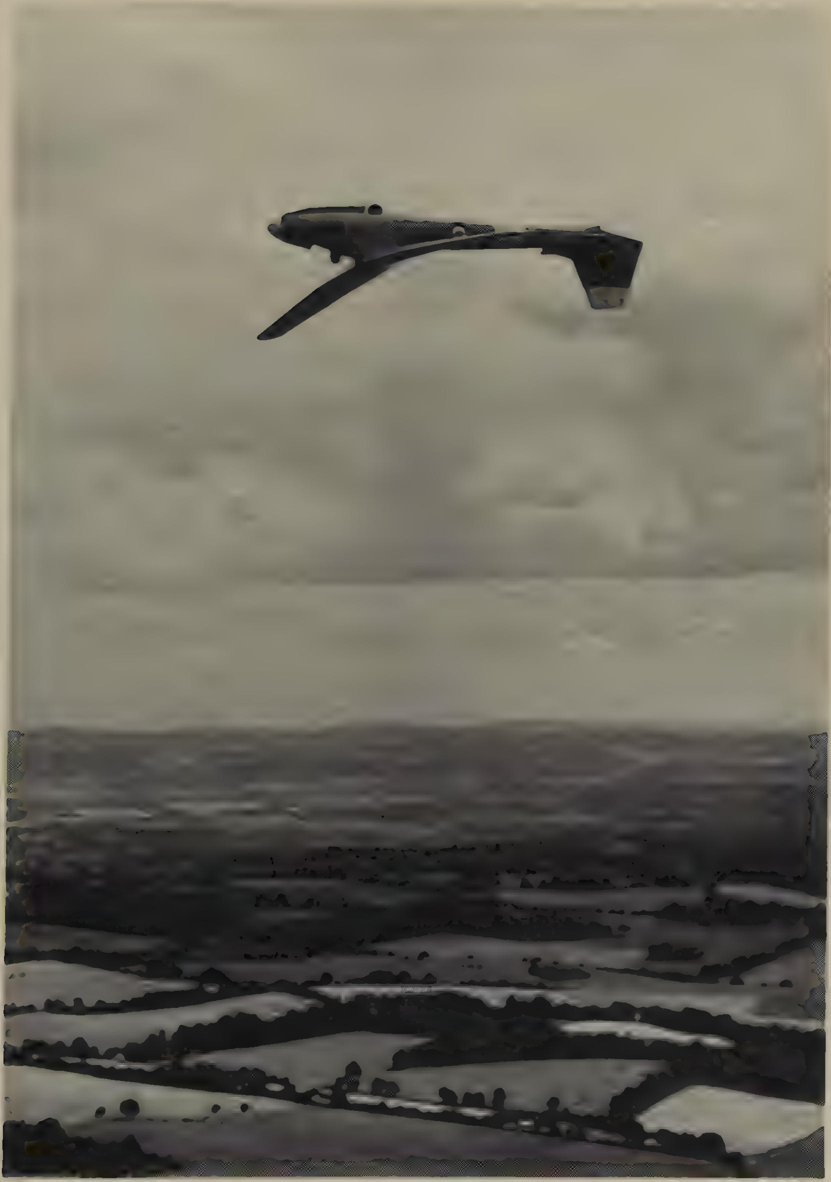
During this stage of a pilot's career, it is a good idea to make every approach without the use of the altimeter. Eventually, the pilot should be able to make a good landing in a chosen position on every flight.

On a day with a light wind, it is possible to fly 30 or 40 miles without being out of gliding range of the take-off point. If the turning points for a triangular flight are selected carefully so that all three are about seven miles from the site, a height of 4,000 feet will be sufficient to keep within gliding range throughout the flight. This is an excellent opportunity to practise photographing turning points quickly ready for later attempts at larger triangles.

If, through a bad error of judgement, it becomes doubtful whether it is possible to reach the gliding site, the safety of the glider must be the main consideration. A suitable field should be selected in plenty of time in order to ensure a safe landing. Never risk a landing on the fence or just short of the site by hoping that there will be lift to help the glide. The slightest risk of damage to the glider is far worse than an unauthorized landing in a field.

EFFICIENT CRUISING

A pilot should know sufficient about the performance of his machine to make the most of varying conditions.



Aerobatics are fun!
A Skylark caught at the top of the loop

Photograph by Charles E. Brown

The gliding angle is measured as a ratio of the distance travelled for the height lost, e.g. 30 : 1. It varies considerably at different flying speeds and depends upon the ratio of the lift and drag. The best gliding angle occurs when the lift/drag ratio (L/D) is at a maximum. This is usually about 15 m.p.h. above the stalling speed. The best gliding angle for a particular type of glider can only be increased by improving the lift or by reducing its drag. (Fig. 45.)

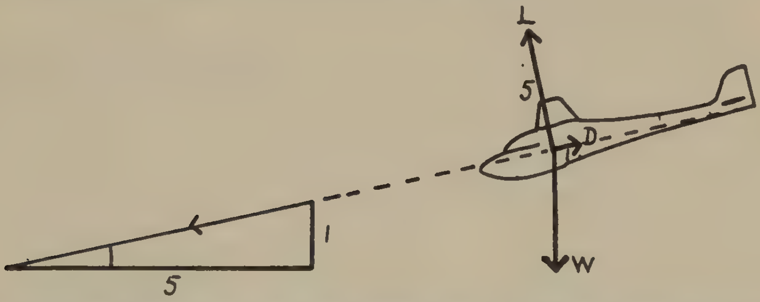


Fig. 45. The gliding angle and the lift/drag ratio. In a steady straight glide the gliding ratio is equal to the ratio between the lift and drag of the glider (5 : 1).

The rate of descent depends on the gliding angle and the flying speed.

A low rate of descent can be obtained by building a light glider with a large wing area, but a flat gliding angle is only possible by careful design and construction for low drag. A simple strutted glider such as the Tutor or Grunau Baby with a gliding angle of 16 : 1 at 30 m.p.h. has the same rate of descent as a high performance machine with a gliding angle of 27 : 1 at 50 m.p.h. The latter has almost twice the chance of finding a thermal but costs almost three times as much to build.

Many pilots are puzzled by the fact that the best gliding angle is unaffected by an increase in weight. The extra weight requires a higher flying speed to obtain more lift, but as both lift and drag are proportional to the square of the velocity, the ratio between the lift and drag remains the same. The rate of descent will have increased although the glider will still fly the same distance from a given height. The increase in flying speed is an advantage when flying against a strong wind, whereas a low rate of descent is valuable when the thermals are very weak. Gliders of advanced design sometimes carry water ballast tanks so that the load can be varied according to conditions. When the tanks are full, the increase in sinking speed is insignificant while the thermals are strong and the raised cruising speed is an advantage. When the strength of the thermals decreases, the water can be released and the lowered sinking speed will help the glider to keep up.

Fig. 46a shows estimated performance curves for a Skylark 2.

The top curve shows the glide ratio and the lower curve the rate of sink of the glider, at various speeds.

The minimum rate of sink occurs at point *A* which corresponds to about 43 m.p.h. This is slower than the speed for the best gliding

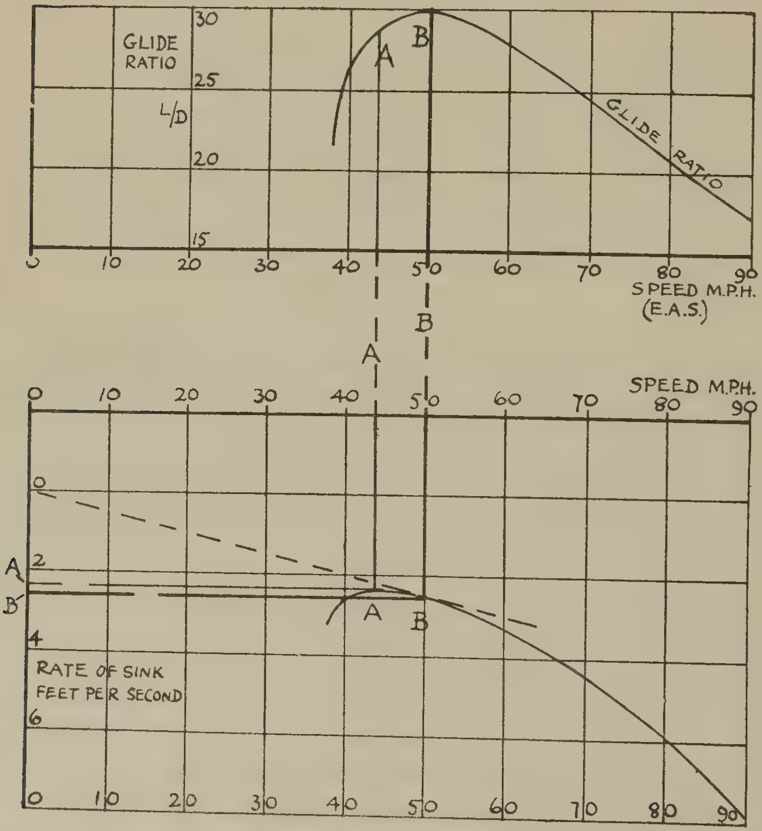


Fig. 46a. Estimated performance curves for the Skylark 2. A is the speed for the minimum rate of sink and B is the speed for the best gliding angle.

angle *B* 50 m.p.h. The slightly steeper gliding angle at *A* is more than offset by the reduction in flying speed and results in a lower rate of descent. (See Fig. 46b.)

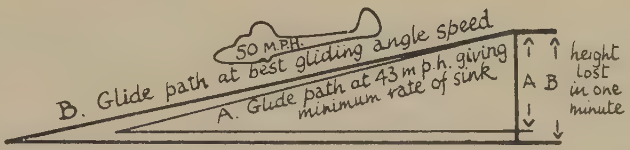

50 M.P.H.
B. Glide path at best gliding angle speed
A. Glide path at 43 m.p.h. giving minimum rate of sink
A
B
height lost in one minute

Fig. 46b. The minimum rate of sink occurs at a lower speed (A) than the speed for the best gliding angle (B).

The effect of an increase in all-up weight of the glider is to displace the gliding angle curve to the right and the sinking speed curve down and to the right.

It is not difficult to determine the best speeds to fly in various circumstances and the following diagrams explain the principal cases and the rules to be applied. The exact speeds are not very important for local soaring because the wind strength and the strength of any down draught are seldom accurately known.

TRIMMING

The beginner will always find it easier and more pleasant to retrim the glider whenever there is a noticeable stick load. However, with a conventional tailplane, elevator and trim tab, the tab is then at an angle to the elevator and this creates additional drag, particularly at high speeds. For competition purposes, therefore, the trim tab should be centralized and the extra stick force accepted for any long, straight glides.

However, if an all-moving tail plane with anti-balance tabs is fitted (Slingsby Dart, Austria, etc.) the lowest drag will always occur when the glider is correctly trimmed, since this is when the tabs are exactly lined up with the tailplane. In this case bad trimming is a cause of extra drag.

DETERMINING THE SPEED TO FLY FOR MAXIMUM DISTANCE IN VARIOUS CONDITIONS

(See Fig. 47)

a. In still air. Fly the speed for best L/D to cover the greatest distance for a given loss of height. (Usually about 15 m.p.h. above the stalling speed.)

Draw the tangent from the origin O to touch the curve at *B*. The speed for best gliding angle in still air corresponds to the point *B* on the curve.

b. In sinking air. Increase speed to fly through the sink with the minimum loss of height.

Measure off the down-draught strength *OV* above the airspeed axis. Draw the tangent *VC* to the curve. The best speed corresponds to the point *C* on the curve.

c. In weak rising air. Reduce speed to just above the speed for minimum sink and circle if the lift becomes strong enough and more height is required.

Measure off the up-draught strength *OW* below the airspeed axis. Draw the tangent *WD* to the curve. The best speed corresponds to the point *D* on the curve.

d. Against the wind. Increase speed to best gliding angle plus one-third of the wind speed.

Measure off the wind strength *OX* along the airspeed axis. Draw the tangent *XE* to the curve. The best speed corresponds to the point *E* on the curve.

e. With the wind. Reduce speed to just above the speed for minimum sink.

Measure off the wind strength *OY* in the negative sense along the airspeed axis. Draw the tangent *YF* to the curve. The best speed corresponds to the point *F* on the curve.

f. Against the wind in sinking air. Increase speed to well above the speed for the strength of the head wind.

Measure off the wind strength *OX* (as in *d*) and the down-draught strength *OV* (as in *b*). From *Z* corresponding to points *X* and *V*, draw the tangent *ZG* to the curve. The best speed corresponds to the point *G* on the curve.

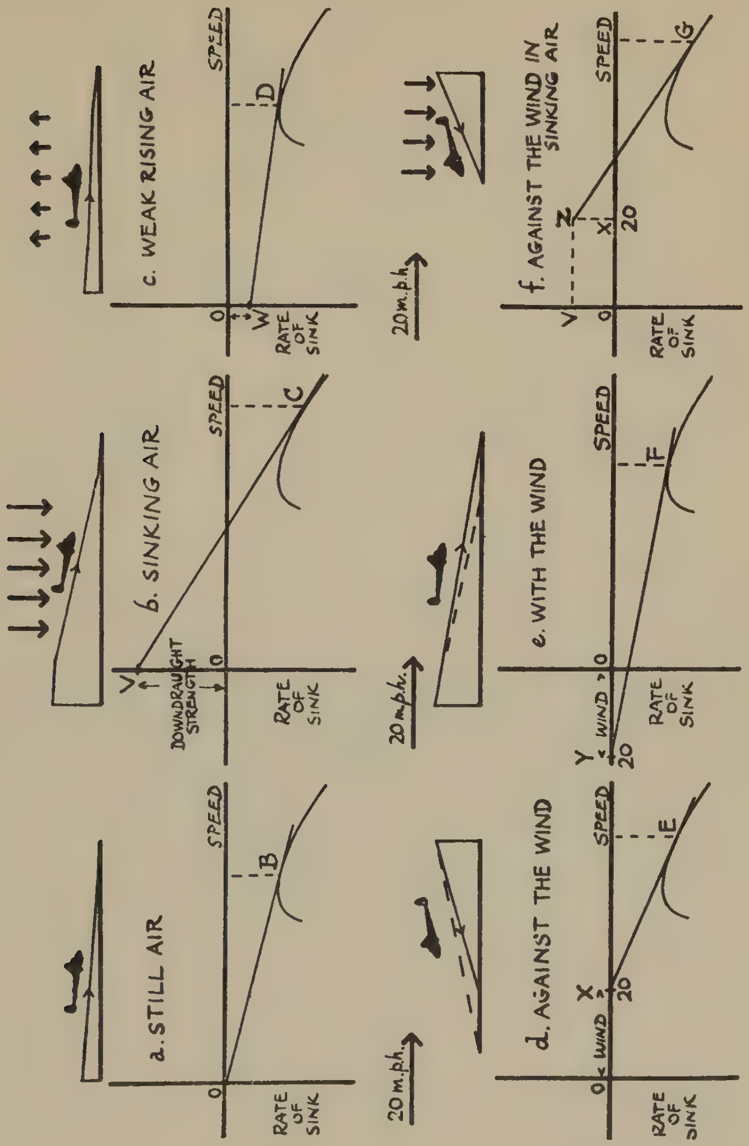
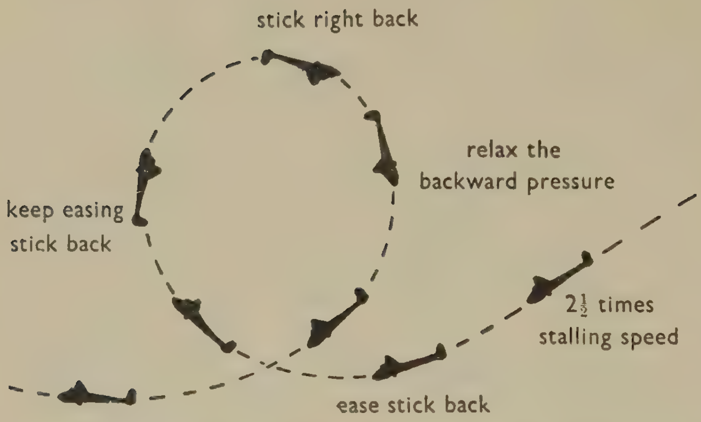


Fig. 47. Determining the speed to fly for maximum distance in various conditions by means of the performance curve.

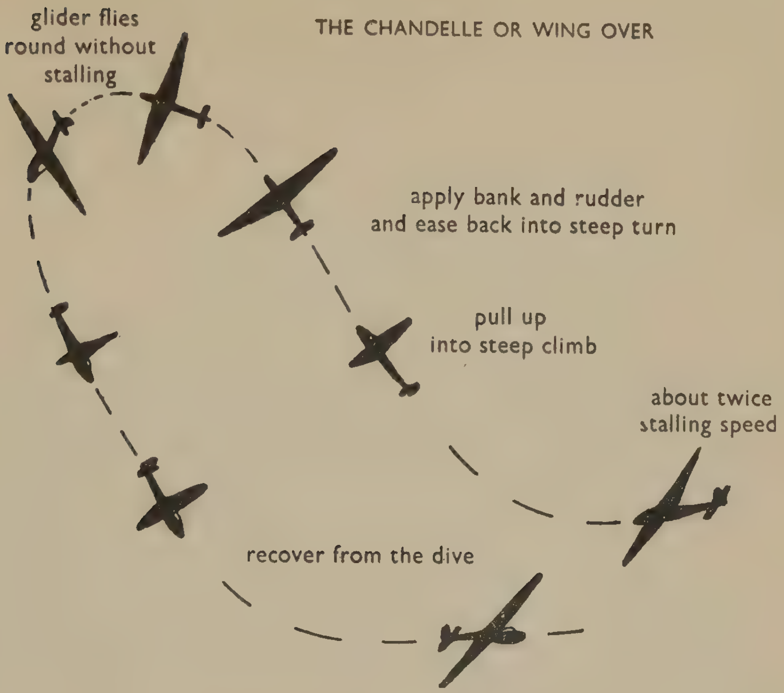
AEROBATICS

THE LOOP



Most modern gliders are permitted to carry out simple aerobatics such as loops and chandelles but are not designed for slow rolls or inverted flight. The limitations of the particular type of glider are clearly stated on the cockpit placard. Aerobatics should not be carried out in turbulent conditions and care must always be taken not to exceed the maximum permitted speed for the type of glider. The controls should be moved smoothly but firmly.

If at any time during aerobatics a very steep stall or a tailslide seems imminent, the pilot should centralize the controls and hold them firmly to prevent them flapping against the stops and damaging the hinges. The glider will fall into a steep dive from which a normal recovery can be made.


THE CHANDELLE OR WING OVER
glider flies round without stalling
apply bank and rudder and ease back into steep turn
pull up into steep climb
about twice stalling speed
recover from the dive

Stall turns are not recommended for gliders because there is a serious risk of the glider tail sliding. The chandelle or wing over is a much safer manoeuvre which is just as spectacular to the onlooker and requires skilful piloting.

Section III

EXPLORING THE SKIES

Having mastered the elementary principles of gliding, you can now begin to enjoy the rewarding pleasures of soaring flight.

At most of the larger clubs, there are schemes for advanced instruction to prepare you for cross-country flying and you are advised to take advantage of them, particularly if you intend to buy a glider or a share in one.

The majority of modern high performance gliders are easy to fly and safe enough for even inexperienced solo pilots. However, they can be very expensive and even dangerous unless you are prepared to limit your activities to local flying until you have at least 20 hours of solo flying and have been systematically trained to deal with the problems of field landings.

Since much of the fun in gliding comes from the competition with the other club members, most people prefer to use club machines for their first soaring season before even considering the possibility of joining a syndicate or buying a private glider.

CHAPTER 19

THERMALS

How a thermal is formed—Cumulus clouds—Where to find thermals—Surface heating—The contours of the ground—The type of soil—The wind—Coastal effects—Visible indications of thermals—Isolated thermal bubbles

A THERMAL is a mass of air which ascends because it contains water vapour or is warmer and therefore is less dense than the air around it.

As the thermal rises, it mixes with the surrounding air and grows larger. Usually it seems to break away from the ground as a bubble and then it develops into a doughnut or vortex ring shape which gradually grows in size as it gains height. In hot climates the thermals may take the form of long columns, but in British conditions there is ample evidence to suggest that the thermals are of bubble form. (Fig. 49.)

The reduction in the atmospheric pressure with height causes both the thermal and the surrounding air to cool down with height. Unless the air is very dry, the moisture in the thermal will eventually condense out to form a cumulus cloud. As this happens, the latent heat absorbed when the moisture was evaporated on the ground is released. This extra heat helps to strengthen the lift in the cloud while the cloud is developing.

The life of a cumulus cloud is of particular importance to the glider pilot. The first sign of the cloud is a patch of milky haze; then wisps of cloud form which rapidly develop into a firm looking cloud with a flat base and rounded top; after about ten minutes, the edges and bottom of the cloud become ragged and the cloud quickly erodes and disappears.

Sometimes this process is prevented by a fresh thermal revitalizing the cloud or, if the cloud is a large one, it may develop on one side and dissolve on the other. Large cumulus clouds have a number of cells at different stages.

When the air in the cloud starts to descend, the cloud begins to evaporate and this will absorb large quantities of heat. The cooling of the air because of this evaporation will cause strong down currents.

Elsewhere there is a more gradual subsidence of the air which compensates for the rising air in the thermals.

The glider pilot must, therefore, learn to distinguish which clouds are still developing, and must avoid flying near any which have started to decay.

The stability of the air varies from day to day and governs the strength and height to which the thermals will go. Unstable air produces good thermals with showers or thunderstorms if there is sufficient moisture for their development. Stable air prevents the formation of thermals.

Cumulus type clouds occur when the upward movement of the air is rapid and the air is unstable; whereas stratus or layer type clouds are formed when the air is stable and rises more gradually. For example, layer cloud will form when the air is lifted over rising ground or a very shallow wedge of colder air.

The general characteristics of a thermal vary considerably in different conditions. Some thermals are large and smooth, and others narrow and turbulent. In good conditions the rate of ascent of the air may be as high as 20 feet per second, giving the glider a rate of climb of over 900 feet per minute. (This compares favourably with the rate of climb of a light aircraft.) In thunderstorm conditions rates of climb of 2,000 feet per minute are not abnormal.

The size of the thermal is important from the glider pilot's point of view since, to make effective use of it, the glider must be able to keep inside its bounds. Below about 500–600 feet, most thermals are either too weak or too narrow for the average glider to use effectively. The thermal is drifted down wind as it rises, so that any cumulus cloud formed will be down wind of the thermal source. For example, in a 15 knot wind, a thermal giving 4 knots rate of climb in the core, the whole bubble may be ascending at less than 3 knots or an angle of only 1:5 from the source.

WHERE TO FIND A THERMAL

If cumulus type clouds are forming, clearly the best method of finding a thermal is to search underneath or close to the cloud for the thermal which is producing it. However, on many occasions there are no clouds, and the pilot is forced to transfer his attention to the ground in order to try to discover the most likely place for the production of thermals.

Since the thermal is produced by the air in one area becoming warmer than that surrounding it, it should be possible to decide on the most likely places for this to occur. Unfortunately, there are so many interdependent factors involved that it is impossible to give any rules. However, the pilot who knows the area over which he is gliding has a distinct advantage, since good thermal producing areas give off thermals at fairly regular intervals on most unstable days.

The factors generally accepted as affecting the source of thermal production are:

a. The intensity of the heating by the sun and other sources of local heating.
b. The contours of the ground.
c. The type of soil, crops, or surface of the ground and the effect of colour contrast of them.
d. The wind strength and direction.
e. Coastal effects.

a. Heating

The essential condition for the production of a thermal is that one mass of air should become warmer than the air surrounding it. The actual temperature of the main air mass is unimportant and, in fact. thermals can be found in both tropical and arctic conditions.

When the heat and light waves from the sun strike the ground, some are absorbed and raise the temperature of the surface, but the rest are reflected back into the atmosphere and dissipated. The increase in temperature of the ground will vary with different surfaces and with the intensity of the radiation.

If the heat waves have to pass through a layer of cloud or dust before reaching the earth, a large proportion of them are scattered and do not reach the ground. A thin layer of cloud or the smoky haze down wind of an industrial town can prevent or seriously limit thermal activity, and these conditions may often act as a barrier preventing progress on a cross-country flight.

During the course of a good soaring day with the development of cumulus clouds, there are often several periods when the cloud develops to such an extent that it completely cuts off the direct sunlight. This results in a period of poor conditions as the cloud disperses and is followed by a gradual improvement to another peak of activity. This "over-development" as it is known in gliding circles, spoils many otherwise promising days. It generally occurs when the air is very moist and when the forming cumulus is prevented from developing vertically by a stable layer. Where the cloud forms just below a layer of stable air, the cloud cannot develop upwards and spreads out rapidly, often forming a complete cover in less than twenty minutes. Usually, on a day when the cumulus cloud develops quickly early in the morning, (apparently promising a perfect day for soaring) there is more likelihood of the cloud over-developing, so that by midday conditions will have deteriorated.

The shape and form of thermals is very complex and variable and there seem to be no hard and fast rules for their development. However, on a particular day, the position of the best lift will usually be found to be consistent in relation to the clouds and cloud shadows. Even isolated cloud shadows have a significant influence on thermals. The pilot should try to analyse the position of the best lift relative to the cloud on the first few thermals used.

In clear air, very little of the sun's radiation is absorbed before it reaches the ground and the surface heating will be strong. Unfortunately, in anticyclonic conditions, although often the sky is clear and the sun's heat intense, the air may be very stable and the thermals poor or non-existent.

The amount of radiation absorbed by the earth also depends upon the angle at which the sun's rays strike the ground. In winter, the days are very short and by the time that the ground has become warm enough to set off the thermal activity, the sun is beginning to go down again. It is most unusual to get good thermal activity for cross-country flying in Great Britain during the winter months.

In hilly country the surface heating will be much greater on slopes facing south, where the sunlight strikes the ground almost at right angles. This, together with the prevailing south-westerly winds in this country, make a south or south-west facing slope ideal for hill and thermal soaring sites.

Factories, towns and heath fires are reliable thermal sources used by gliders, although compared with the enormous heat output of the sun, the heat from factory chimneys, etc, is small and is seldom sufficient alone to produce continuous thermals either strong or wide enough to be of use to a glider. Even without their artificial means of heating, factories and towns are in themselves good sources of thermals when warmed by the sun, so that in doubtful circumstances it is always worth trying the area just down wind of such places, where the sun's heating is boosted by artificial heat.

If the air is stable, even the hottest factory chimney or sun-scorched area will not provide a useful thermal. It is, therefore, well worth while consulting the nearest Meteorological Station before announcing a record-breaking cross-country attempt. However, the forecaster, who is used to dealing with powered aircraft, may refer to the conditions as being stable when a thin layer of dry unstable air to 3,000 or 4,000 feet is lying below very stable upper conditions. Such a day might, in fact, give excellent soaring up to that height. (This would happen if the stability of the upper air kept the sky clear of cloud and allowed uninterrupted sunshine.)

b. The contours of the ground

Usually, high ground or hilly ground is good for producing thermals, and thermals starting from hill tops are likely to be stronger than those originating from the adjacent valleys. There are several reasons for this. High ground is usually better drained than low-lying land and, therefore, warms up more rapidly. Also, although the sun's radiation will raise the temperature of similar ground in the valley and on the hill top by the same amount, a thermal leaving the valley will have lost part of its heat by the time it has risen some way above hill-top height. It will therefore be cooler, and weaker above that height than a thermal starting from the hilltop.

If warmed air is blown up the slope, it is given the initial upward movement necessary to start it breaking away from the ground. This makes it possible to soar above a suitable hill in very light winds.

Air which has been gradually warmed up may often remain on the ground for some time unless it reaches a high temperature or is disturbed. In windy weather, the layers of air in contact with the ground are constantly being disturbed so that it is difficult for large areas of air to accumulate and warm up sufficiently to produce a good thermal. Where the country is hilly, the warm air is often able to lie undisturbed in the lee of a hill or in any small valleys, and these areas become good thermal sources in windy conditions. These are generally known as "wind shadow" thermals.

Where a thermal forms and is blown over the top of a ridge of hills, it may be broken up by the strong turbulence or "curl over" effect just behind the crest of the hill. If the thermal is large, it will reform as soon as it has passed the turbulent area, but in many cases it is broken up so much that it becomes useless for soaring. This phenomenon gives the impression that the thermal has been lost but, if height permits a few minutes continued circling, the lift may reappear when the glider and thermal have drifted farther down wind.

The increase in surface heating on a south-facing slope has already been mentioned and this effect will become very marked when combined with a "wind shadow", i.e. when there is a light northerly wind so that the south face of the hill is also in the "wind shadow".

c. The type of soil and surface

The type of soil, the surface and the crops all have a very marked influence on whether a particular area will be a good thermal source. It is difficult to assess this from the air unless the area has much concrete or metal, which always heats up rapidly and is a reliable source of thermals in sunshine.

Sand and chalk soils are good thermal producers whereas clay is generally poor. A study of a geological map is often valuable when planning a long-distance flight. It may indicate the ranges of hills and high ground and will show the changes in subsoil and rock.

Drainage is often the most significant factor of all and even a slight shower will cool the ground sufficiently to prevent thermals forming for some time afterwards.

A dark surface will absorb more heat than a light one, but the effect of this may be offset by the ground being damp or covered by various types of crops which all affect the rate at which the ground will heat up.

Woods are very slow to warm up, and usually are much cooler than any surrounding fields until late in the afternoon. Once they have warmed up, they give off their heat slowly and remain much warmer than their surroundings later on in the day. This is because the trees trap large quantities of air which take a long time to warm up. It is difficult for this air to escape as it is protected from the wind. Thermals from wooded sources generally seem to be large areas of very weak lift which are often best used by cruising without circling. If the woods are extensive, a slight diversion to fly over them may enable the flight to be carried on for many miles at a time late in the day when all other thermal activity has died out.

Long corn and similar crops can trap large quantities of air and prevent it from breaking away from the ground until it has reached a high temperature, giving good thermals.

A rather interesting example of thermal production is the formation of dust devils on hot summer days. When the surface heating is very intense, and the wind is very light, the surface of the ground reaches extremely high temperatures. If the air is very unstable, a small dust devil may develop in size until it becomes a freak storm or whirlwind capable of damaging buildings or overturning gliders. Special care must be taken to picket gliders securely on hot, calm, thermic days as the surface wind may change without warning and blow over an unattended glider. This is a frequent cause of damage to gliders in the tropics.

d. The wind

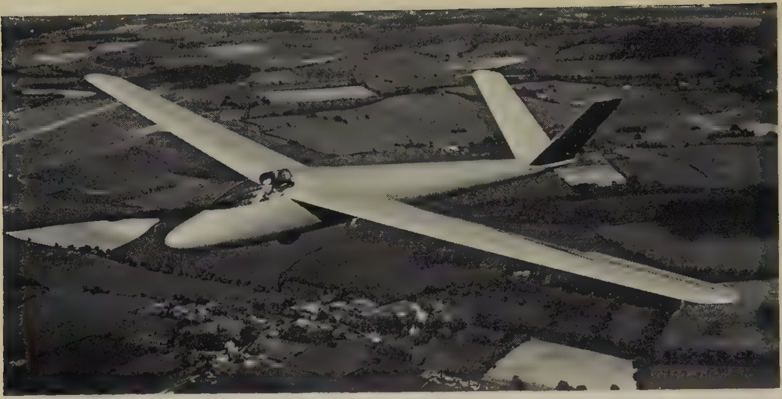
The wind strength and direction is, as already stated, an important factor in determining where thermals will be produced in hilly country.

In open fields, the effect of the wind blowing over a row of trees or other obstructions often disturbs the warm layer of air close to the ground. This is a most noticeable feature on aerodrome sites. Aerodromes are well drained and provide an almost continuous stream of warmed air, which is swept by the wind over the obstructions on the down-wind boundary giving a stream of weak lift. This is encountered on nearly every approach and causes much frustration, as although it comes when the glider is too low to soar it upsets the approach.

High winds make it difficult for large thermals to exist near the ground, although even on the windiest days there may be strong lift just below the cumulus clouds. Since the rising air drifts with the wind as it gains height, it is often difficult to know the source of a particular thermal. On calm days, the upper wind is frequently quite different to that on the ground so that the path of the thermal may be quite irregular. Searching for thermals above 1,000 feet is, therefore, mostly a matter of trial and error unless there are cumulus clouds developing.

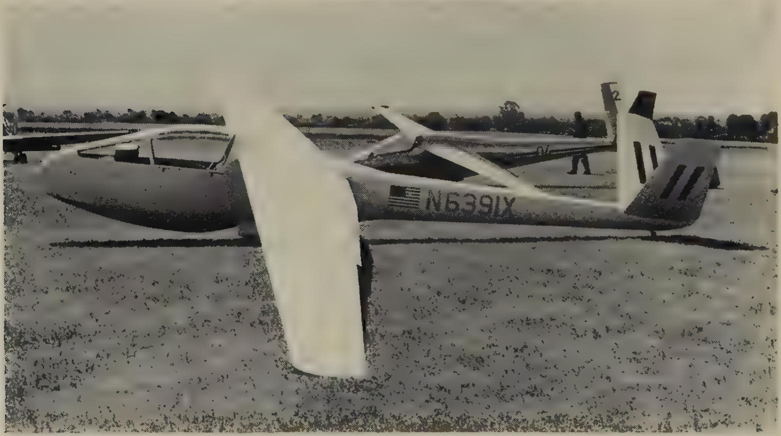
e. Coastal effects

The coast line has a pronounced influence on the formation of thermals. The sea temperature is not greatly affected by the sun's



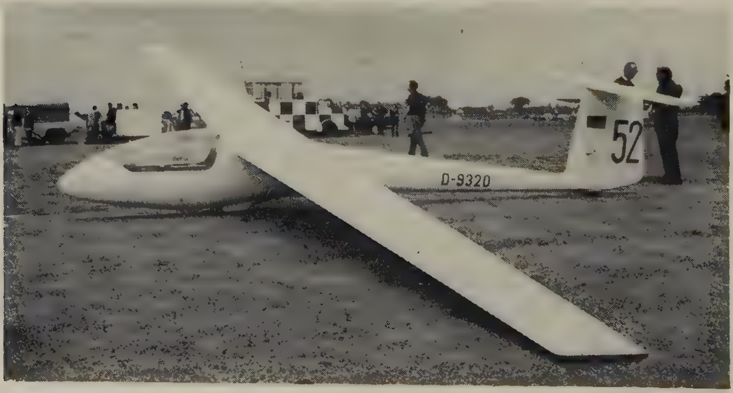
The Standard Austria, mainly of wood construction

Photograph by Charles E. Brown



The American Sisu and the Russian A15, all-metal gliders

Photographs above & below by Sally Anne Thompson



The Phoebus, one of the first production machines of all glass-fibre construction, made in Germany heating during the day and remains at an almost constant temperature. The land soon becomes warmer than the sea, but cools down again at night so that it becomes cooler than the sea once the sun has gone down. This causes the sea and land breezes. The cool air from the sea takes some time to warm up enough to produce thermals so that, with an onshore wind, few thermals are formed within about five to fifteen miles of the coast. If the wind is blowing offshore good thermals are possible near the coast and the contrast between the ground and sea temperature produces a band of thermal lift just over the sea. Although sometimes only just strong enough to support a glider, this lift can be used by flying along it without circling, which enables long distances to be covered very quickly. Where the sea breeze meets the normal air mass, the cool air from the sea forms a wedge which forces up the warmer unstable air and produces exceptional soaring conditions along a belt parallel with the coastline. This area of rising air is often marked by a line of larger cumulus cloud or by a line of wispy cumulus cloud forming well below the normal cloud base. Little or no thermal activity is to be found beyond

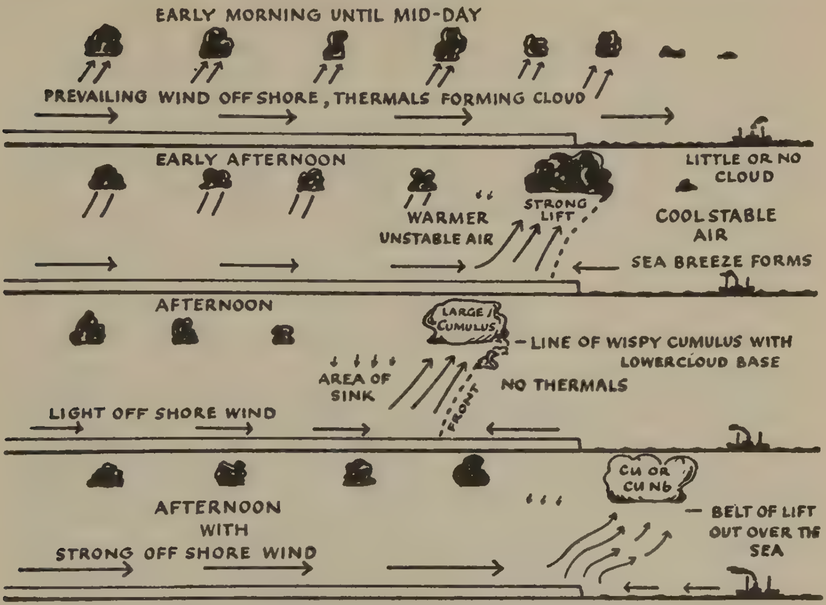

EARLY MORNING UNTIL MID-DAY
PREVAILING WIND OFF SHORE, THERMALS FORMING CLOUD
EARLY AFTERNOON
LITTLE OR NO CLOUD
STRONG LIFT
WARMER UNSTABLE AIR
COOL STABLE AIR
SEA BREEZE FORMS
AFTERNOON
LARGE CUMULUS
LINE OF WISPY CUMULUS WITH LOWERCLOUD BASE
AREA OF SINK
NO THERMALS
FRONT
LIGHT OFF SHORE WIND
CU OR CU Nb
AFTERNOON WITH STRONG OFF SHORE WIND
BELT OF LIFT OUT OVER THE SEA

Fig. 48. The development of the sea breeze front.

the front. On hot days with light offshore winds, the sea breeze front may penetrate thirty to forty miles inland during the daytime. It moves inland more rapidly if the coastline is parallel with the prevailing wind and the frontal effect is less marked.

The influence of the coast line is important on long cross-country flights in England, because the coast line usually limits their distance. Gliding sites near the sea are generally poor for thermals unless the wind is blowing offshore, and this restricts cross-country flights.

VISIBLE INDICATIONS OF THERMALS

Often the problem in soaring is to make contact with a thermal from the limited height of the launch. Visible indications of the whereabouts of a thermal will enable the glider pilot to find one more easily, and once a height of 2,000 or 3,000 feet has been reached there is every chance of finding another.

The formation and development of cumulus cloud indicates that a thermal has recently left the ground. In some conditions cloud does not form but a milky patch of haze may be noticeable if there is not quite enough water vapour to produce a proper cloud. Wearing polaroid sunglasses will help to make these haze patches more visible. In conditions when very thin clouds are forming the pilot must aim for the haze patch before it becomes distinct wisps of cloud. By the time that the cloud has formed the lift may be finished and only sinking air will be found. These clouds should therefore be avoided.

Birds are keen on thermal soaring and have an uncanny instinct for finding thermals. Circling birds are a sure sign of rising air although quite often the area of the lift is too small to be of much use. Swallows flying high indicate lift and, in fact, few birds take the trouble to climb high except by using thermals.

The observant glider pilot can gain a great deal from watching the birds and sharing their thermals. It is always worth while to move into their part of the lift even if you are climbing rapidly. If, by chance, you happen to be going up faster than they are, they will be quick to join you. If there are a large number of birds, or several groups, they will all join those in the best area of lift. This is noticeable abroad where there are more soaring birds, and Phillip Wills has referred to the habits of the vultures who fly for miles to join other birds in a good thermal.

If the thermal is strong, dust and pieces of paper may be carried up giving a clear indication of its position.

Perhaps one of the most noticeable indications of thermals leaving the ground on a comparatively calm day is the variation in surface wind. The occasional cool breeze felt on a summer day is the air moving in to take the place of that rising in a thermal. Since it blows in toward the thermal, it is possible for a glider taking off within a short time, to fly over to the area and find the lift. The indications of two or three windsocks placed round the field will also show changes when a thermal leaves the ground near by, and in a similar way smoke gives an excellent indication.

Various methods of marking a thermal with strips of paper, smoke puffs, confetti, etc, have been tried, but since the variometer gives ample evidence of the presence of the thermal, there seems little point in marking it. The main need is for some means of finding it in the first place.

ISOLATED THERMAL BUBBLES

Most of our thermals seem to break away from the ground as bubbles and develop an internal motion like a vortex ring. (Fig. 49.)

Unless the bubble is rising very slowly, gliders entering the thermal are carried up rapidly in the strong, central core to the cap, where they collect, climbing slowly together. In this way gliders may soar for long periods without falling out of a thermal, even if it is only 500 to 1,000 feet deep.

In the base region, the inflow helps to centre the glider and improves the climb when the bank is steep. Bad centring results in false variometer readings and misleading sensations as the glider meets the inflow and gains speed and height. These infer that there are two areas of lift, the centre of the thermal, and the place where the inflow is met head on. When entering a thermal, the base can sometimes be identified by a drop in airspeed just before the lift is found. Unless a turn is started immediately, the misleading indications of better lift ahead will take the pilot beyond the real centre.

Notice that in these thermals the best lift is usually to be found near to the stronger sink.

In the cap region, the outflow makes centring difficult and the rate of climb is, at best, the rate of ascent of the bubble, or less than half that in the core. Again the horizontal gradients can cause problems. Entering this region, the increase in speed caused by meeting the outflow gives an impression of lift before the real lift has been reached. A turn at this moment just results in a frustrating loss of height.

Whenever possible, the cap should be left without delay in search of another core. In good conditions, several gliders bunched together circling mark a cap and usually at that level it would only be worth while slowing down and passing through the thermal. However, when the bunching gliders are above your level there is a good chance of finding their core and of climbing quickly to their level.

These characteristics also occur in cloud. The easiest climbs are made by entering the cloud in strong lift when the thermal is self centring. Then, after a while, the lift becomes more broken and weaker and the glider is often thrown out of the side of the cloud as the cap region is reached. Starting in poor lift usually results in a difficult and unsatisfactory climb.

Since all gliders in a thermal tend to collect in the cap within a few minutes, there is a serious risk of collision when even two gliders enter the same cloud.

If the rate of ascent of the whole bubble is less than the rate of sink of the circling glider, a gain of height is only possible in the core of the thermal. Even then the glider is, in fact, gradually sinking down through the bubble instead of rising through it to the cap.

Where the bubble is rising rapidly, the glider will not remain in the core for very long before being carried up to the other gliders in the cap. However, a number of short and apparently rapid climbs seldom achieve a very high average rate of climb because of the time spent looking for lift and centering each time. In these conditions it will pay to come lower so that fewer, longer climbs can be made. These will give a much higher average rate of climb.

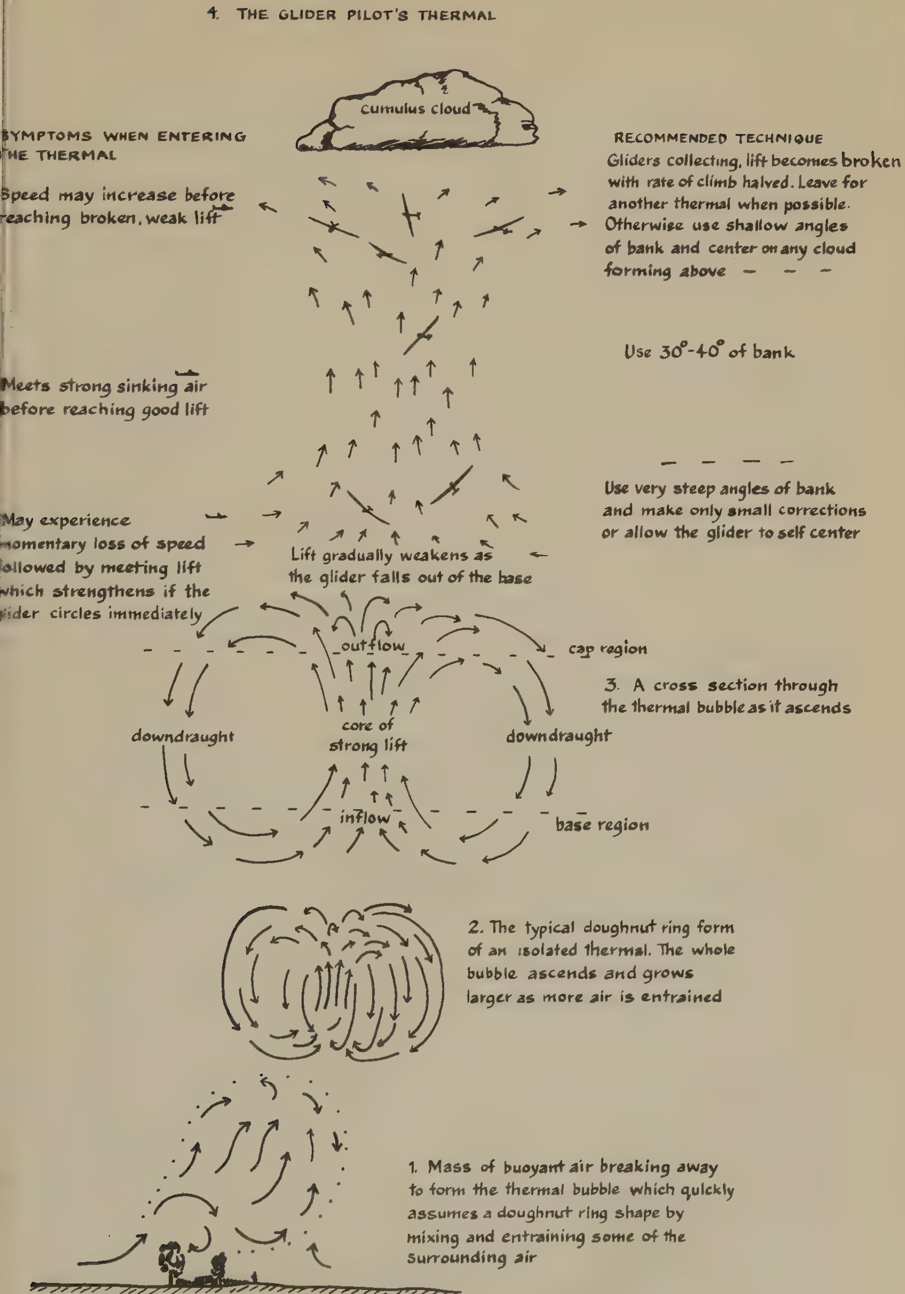

4. THE GLIDER PILOT'S THERMAL
cumulus cloud
SYMPTOMS WHEN ENTERING
HE THERMAL
Speed may increase before
eaching broken, weak lift
Meets strong sinking air
before reaching good lift
May experience
omentary loss of speed
ollowed by meeting lift
which strengthens if the
ider circles immediately
RECOMMENDED TECHNIQUE
Gliders collecting, lift becomes broken
with rate of climb halved. Leave for
another thermal when possible.
Otherwise use shallow angles
of bank and center on any cloud
forming above
Use 30°-40° of bank
Use very steep angles of bank
and make only small corrections
or allow the glider to self center
Lift gradually weakens as
the glider falls out of the base
outflow
cap region
3. A cross section through
the thermal bubble as it ascends
downdraught
core of
strong lift
downdraught
inflow
base region
2. The typical doughnut ring form
of an isolated thermal. The whole
bubble ascends and grows
larger as more air is entrained
1. Mass of buoyant air breaking away
to form the thermal bubble which quickly
assumes a doughnut ring shape by
mixing and entraining some of the
surrounding air

Fig. 49. Isolated thermal bubbles.

CHAPTER 20

THERMAL SOARING

Searching for thermals—Centring—Common errors

If the glider is launched by aerotow to several thousand feet on an unstable day, on most occasions it will meet a thermal during its descent. In the same way, where ridge soaring is possible, the glider is able to keep flying until contact is made with a thermal.

However, when launching by winch or autotow from a flat site, there is very little time to search for a thermal and a sensible search can greatly improve the chances of finding one. It is clear that there is an element of luck in finding a thermal on any particular flight. The luck element is, however, greatly overrated, and it is usual to find that in good conditions, a skilled pilot will find and be able to make use of a thermal at least every third launch, whereas the unskilled pilot may try all day without success.

Since at least 500 feet of height is needed to make use of a thermal, it is obvious that the height gained on the launch is of great importance. A glider launched to 1,500 feet instead of 1,000 feet will have double the chance of finding a thermal.

It should be obvious that the glider with a flat gliding angle will be able to search a larger area for a given launch height. Although even an open primary glider can use thermals, the chances of it finding them are poor, and only a strong thermal will result in a climb.

If no thermal is found during the flight, the glider must be in a position to make a normal approach and landing. If one is found, the glider should be able to climb as high as possible before drifting down wind of the field. Ideally, then, the search should be made up wind of the launch point so that the wind will gradually drift the glider down the field as it gains height. At any time, the circuit may be joined without the necessity for a complicated approach and the need for S turns.

The pilot must be able to fly the glider smoothly at a steady speed and be able to enter turns quickly and accurately. He must also cultivate the ability to read the variometer at a glance so that he can fly accurately, keep a sharp look out for other aircraft, and at the same time keep a constant picture of the variometer readings.

On many occasions, strong turbulence and an abnormally high rate of climb at the top of the launch may indicate that the glider has been launched into a thermal. In this case it is always worth while circling immediately after release in the hope of flying back into the area of lift. It is not advisable to release before the full launch height has been gained as the extra height increases the chance of the thermal being large enough to be used easily.

Unless a total energy variometer is used, the reading of the variometer just after release should be ignored. While the excess speed is being used up, the variometer will show a climb which can easily be mistaken for a thermal. If no lift is encountered at the top of the launch and no particular area is favoured as a likely thermal source, a systematic search should be made up wind of the airfield.

The glider should be flown at the speed for best gliding angle so that the maximum amount of air is covered. If the rate of sink of the glider is abnormally high, indicating that the glider is flying through sinking air, height will be conserved by flying a little faster for a few moments to reach better conditions. If rising air is encountered, even if it is too weak to result in anything but a reduced rate of sink, speed should be reduced to that which gives minimum sinking speed (about 8–10 m.p.h. above stalling speed in most gliders).

The search should consist of a cruise over the area considered most likely to produce a thermal, preferably returning to a position off to one side of the winch at about 600 feet so that a normal circuit and

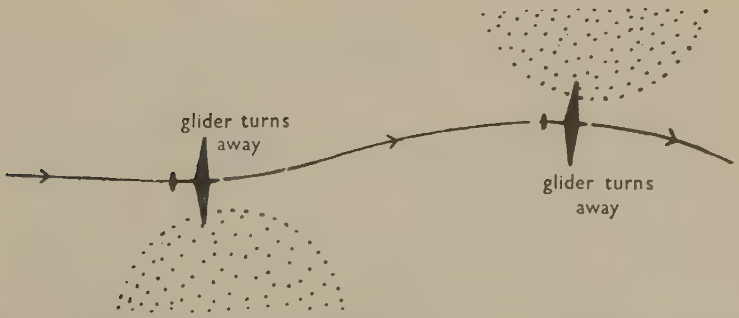


Fig. 50. When searching for a thermal, do not allow the glider to wander or it will find its way between the thermals.

landing is possible. The aim should be to cover as much air as possible and no circling should be carried out unless lift or delayed sink is found. Circling flight outside a thermal is a quick way of losing height without searching any new area.

During the search, it is important to fly the glider in straight lines and not to let it turn. Otherwise, it will wander or turn away slightly as it is affected by the outskirts of the thermals. Inexperienced pilots often unconsciously let the glider influence them into commencing a turn when it is banked almost imperceptibly by lift. In this way the glider will find its way between the thermals. (See Fig. 50.)

The height obtained on a car or winch launch gives a good chance of finding one thermal on each flight. If rising air is found and is discarded without gaining height, there is usually very little hope of finding another thermal before having to land. It is important, therefore, to work any lift encountered and not to assume that something else will be found by further searching during that circuit. Higher up, the pilot can be more selective and use only those thermals which give a good rate of climb, but low down it pays to work each thermal as though it were the only hope.

Reduced sink may indicate that the glider is on the edge of a thermal, or that a thermal is just forming or has just petered out, A turn should be made *immediately* to explore the surrounding area for stronger lift. Since the standard type of variometer has a slight time lag before the true indication is shown, it is important to apply the bank quickly. Unless this is done, the glider may be some distance from the thermal by the time a smooth and accurate turn has been obtained. Many pilots wait until the variometer actually shows a rate

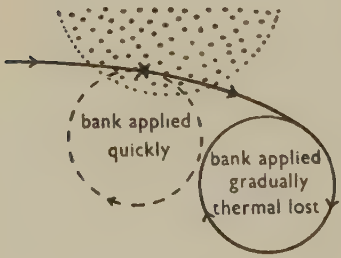


Fig. 51. Apply the bank quickly.

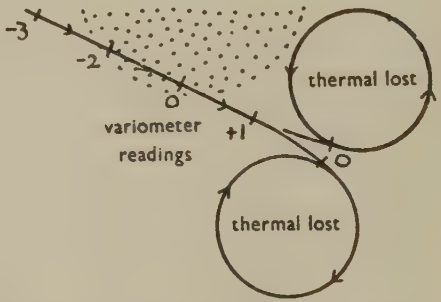


Fig. 52. Do not wait for the best variometer reading before starting to turn.

of climb before starting to turn and they ignore a reduced rate of descent. Any reduction in the normal rate of descent of the glider, which is about 3 feet per second at cruising speed, indicates rising air which may be the edge of a strong thermal. Unless the glider is turned immediately it may fly out of the edge of the thermal and have little chance of finding it again. Experience shows that nine times out of ten the glider flies across the edge of the thermal in this way so that the chances of soaring are greatly reduced if the pilot waits hopefully for the variometer to show a rate of climb before circling. (See Fig. 52.) Generally, slight turbulence or a sensation of rising will be felt as the lift is encountered. This warns the experienced pilot to prepare to make a turn. If the glider happens to fly through the extreme edge of the lift it may be tipped away from the thermal and a turn should immediately be started towards the wing which was raised. (Fig. 53.) If there are no indications which side the lift is, the direction of the turn is immaterial. The essential thing is to make the turn without delay so that contact with the lift is not lost.

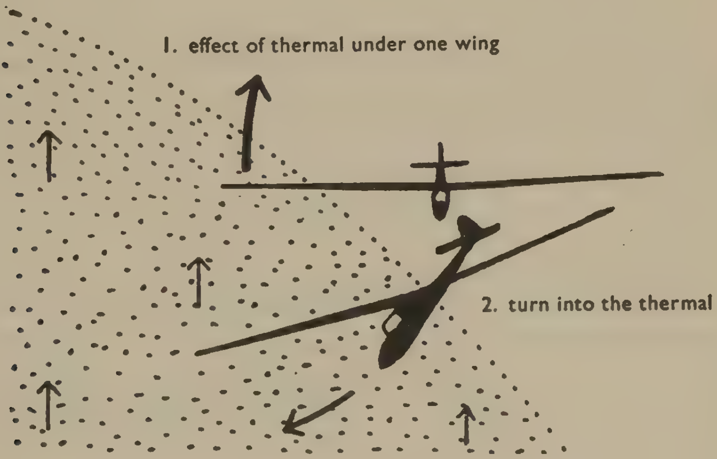


Fig. 53. Turn against any tendency to tip.

Within a few seconds of starting the turn, the variometer shows whether it has been made into or away from the lift. If the turn has been made the wrong way, it is best not to try to change the direction of turn but to keep a steady turn with a constant speed and angle of bank. This will ensure that the glider will come back to the lift again and that there is no chance of losing all contact with it. The most common fault amongst beginners is to start a turn in lift and then to give up and search elsewhere the moment the glider starts to sink. It is wrong to assume that the thermal has been lost or that you were mistaken because the variometer changes to read sink as the turn is initiated. This merely confirms that the lift is on the other side of the circle and that the turn must be opened out away from the sinking air to find it. The problem is then to centre the aircraft in the lift so as to obtain the maximum rate of climb possible.

CENTRING

The principle of centring in a thermal is first to assess the readings of the variometer to find where the best lift lies and then to move the glider over until it is circling in the strongest part of the thermal. As the thermal is normally invisible, and of a small area compared with the amount of air flown through in the course of a few minutes' flight, the problem requires quick thinking and accurate and sensitive piloting.

The beginner should remember that if the lift is of any practical value it will remain useful for long enough to allow time for the glider to be centred stage by stage without any large corrections. Below about 1,500 feet, once the thermal is lost it is most unlikely that it will be picked up again. Therefore, the beginner is well advised to concentrate on careful, accurate circling as this is the key to staying with the thermal.

The radius of turn can be affected by a change in angle of bank, variation in air speed and by inaccuracies such as slipping or skidding in the turn. Unless the bank is held constant and the speed is steady, the turn will be uneven, and this may result in the glider flying out of the thermal altogether. (Fig. 54.) Since the air is generally turbulent in and near the thermal, constant care is required to keep a steady turn. Unless a total energy variometer is fitted, any variation of nose position and speed will cause the variometer to show climb and descent not related to the position of the area of lift. When the nose is pulled up, it will appear that the strongest lift is that sector, but any attempt at centring on these false indications will result in losing contact with the lift altogether.

Fig. 56 shows the method in which the glider is centred into the

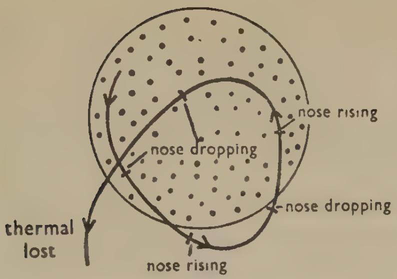


Fig. 54. Variations in speed upset the radius of turn.

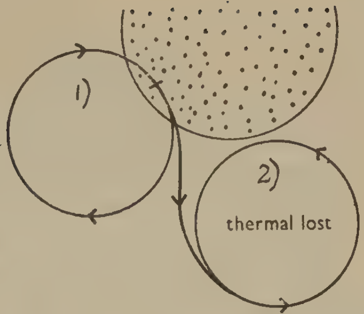


Fig. 55. Do not reverse the direction of the turn.

thermal. The first indication of the thermal is a decrease in the rate of descent together with a slight feeling of buoyancy. In this example the decision was made to turn to the right, and by the time zero sink was indicated a smooth turn had been initiated with about 30 deg of bank and at a speed just above normal cruising. Unfortunately, the turn was away from the lift but as the turn was held, the glider came back into the lift as it completed the orbit.

Since the area of lift is generally small, no attempt should be made to correct an error like this by changing the direction of turn. The poor rate of roll and the difficulty in determining the exact moment to change the turn generally result in the lift being lost altogether as in Fig. 55.

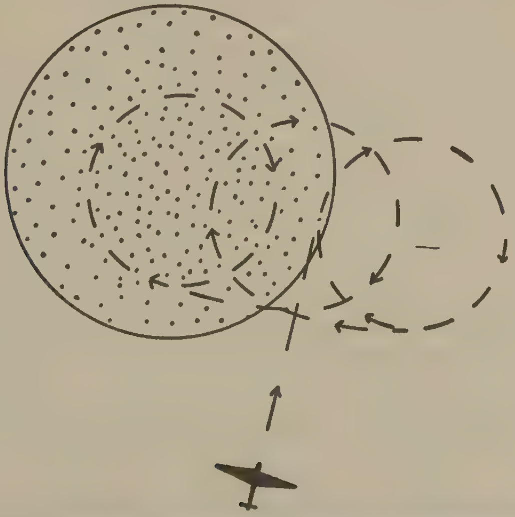


Fig. 56. Centring. The glider is worked gradually into the centre of the lift.

A second orbit can be made checking the variometer readings approximately every 90 deg so that the position of the lift can be estimated. This time, as the glider is approaching the area of lift, the bank should be *reduced for about five seconds* and then, regardless of results, the turn should be resumed as before. This should move the circle nearer to the lift, but even if an error has been made, it is unlikely that contact with it will be lost. Further circles, alternately checking the position and strength of the lift and making corrections, should result in the glider eventually circling with an almost constant rate of ascent all the time. This indicates that either the glider is centred in the thermal or that the area of lift is so large that the whole turn is well inside the lift.

Depending on the particular thermal, it may pay to adjust the angle of bank to see if a higher rate of climb can be obtained.

It is often an advantage to use a steep angle of bank in order to fly in the more powerful core of the thermal. Since the core may have twice the rate of ascent of the rest of the thermal, the slight decrease in efficiency caused by the steep turn is well worth the advantage gained by being able to stay in the stronger lift. If the pilot is unable to maintain an accurate steep turn to stay in the core, it is better to adjust the angle of bank to one which is well within his capabilities.

But if no core of strong lift can be found, try gradually opening out the turn as this will result in a bigger difference in variometer readings on opposite sides of the turn which may make it possible to re-centre more accurately than before. If the area of lift is very wide, opening out the turn will reveal this fact and possibly bring to light a strong area of lift on one side which, otherwise, might be undiscovered.

Since the thermal becomes wider with an increase in height, the angle of bank can be often reduced to advantage above about 1,500 feet.

The position of the best lift in a thermal may change constantly so that the expert will want to adjust his circles all the time in order to achieve the best rate of climb. Obtaining the best rate of climb is an art requiring constant practice, and is the key to successful soaring.

Rapid centring and the highest possible average rate of climb must be the aim of the more experienced pilot. He must not be content with just climbing but must keep exploring the air around to make sure that he is in the strongest part of the thermal.

A useful method of doing this is shown in Fig. 57. The turn is gradually opened out to cover a wide area in search of a stronger core of lift. The moment that good lift is felt, the turn is tightened into a very steep turn in order to centre on that spot. If the variometer confirms a high rate of climb this turn can be continued and the bank reduced slightly to improve the efficiency of the turn and re-centre. However, if the rate of climb is not satisfactory, the turn is again opened out gradually to search again.

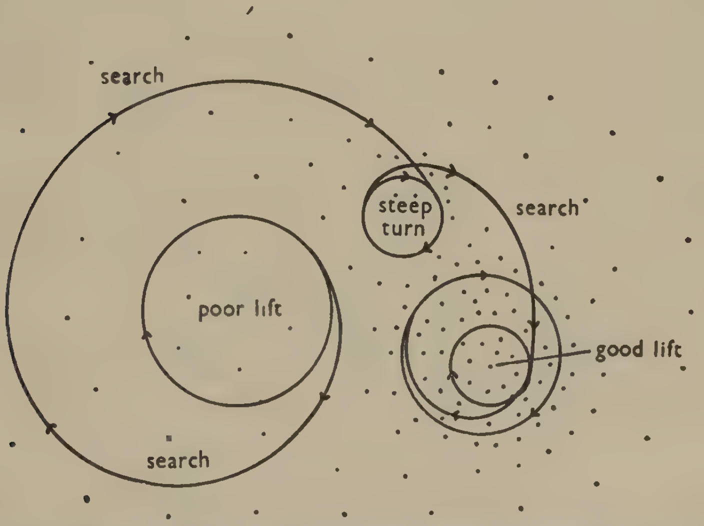


Fig. 57. A method of centring suitable for normal thermalling and cloud flying.

The advantage of this method is that it is based on a certainty. At the moment of tightening the turn, the lift is known to be stronger. The only question is whether the glider can be made to circle in it and also whether the rate of climb is the highest possible.

Either flying too fast or too slow will reduce the rate of climb.

It is definitely detrimental to fly too slowly when soaring. It increases the sinking speed and makes the handling more difficult, so that any turbulence may leave the glider stalled and losing height rapidly. Also the area of lift may be lost altogether during the subsequent recovery.

Flying too fast results in a higher rate of descent and a larger radius of turn, both of which are undesirable when soaring.

The best speed is usually just above the minimum at which no difficulty is experienced handling and at which no pre-stall buffeting occurs.

Thermal soaring is largely a matter of good orientation. The pilot must maintain a mental picture of the distribution of the lift in relation to his circles. This is made easiest by bearing in mind the position of the gliding site, the sun or a cloud. He must also allow for the lag in the variometer when making corrections to the turn and when interpreting his readings.

An experienced pilot can detect changes in the lift by the sensations of acceleration up or down. These feelings are instantaneous and have no lag like a variometer. The electric variometers together with audio attachments have eliminated the need for a good sense of feel which used to be essential for efficient centring.

Because of the lag in some variometers, it is common for them to be indicating a steady climb when for a short period in each turn the glider is actually descending. This can be detected by feel and indicates that the glider is not in the centre of the lift.

Unfortunately, the sense of feel cannot detect very gradual changes in acceleration, and variometer readings have to be used to confirm feelings of lift and sink.

* * * * *

Thermals drift down wind from the ground so that at low levels other thermals from the same source will usually be found up wind of the cloud. During the climb, the glider and the thermal drift down wind together so that a constant turn will normally keep the glider in the lift. However, if the cloud is large, it may often be fed by several thermals which may enter the cloud base at various points or may combine to produce a large area of lift with several strong cores. Sometimes, the lift will peter out just below cloud. A search round below the cloud may result in contacting another thermal which is still feeding into it, but otherwise this is normally a sign that the cloud is fully grown and is beginning to decay, and the glider should be flown on to a more promising area where the clouds are still forming.

The visibility just below cloud base is often poor as the moisture is beginning to condense. Unless the glider is equipped with a turn and bank indicator, air brakes and a compass, it is wise to stop circling and head away while still several hundred feet below cloud. A decision should be made whether to enter cloud long before the cloud is reached. In many areas, cloud flying is prohibited by civil flying regulations, but, in any case, no inexperienced pilot should venture into cloud without a good knowledge of the problems of instrument flight.

After even a few moments in cloud, it is easy to come out heading down wind and some way from the airfield and by the time the airfield is found, the glider may be too far down wind to be sure of getting back. Often the base of the cloud is concave so that an attempt to fly out of the lift may be difficult without having to fly through the cloud. At cloud base, if the air is unstable the lift will become stronger, and even diving or with air brakes out, it may be difficult to keep out of the cloud. If cloud is entered, it must always be remembered that during the course of only a few minutes the cloud can grow to many times its original size. It is not unusual to enter a small patch of cloud expecting to fly through it in a few moments and to fly on for ten minutes or more without sight of the ground, gaining several thousand feet in the meantime.

Although thermals do peter out sometimes after only a few hundred feet and at other times just below cloud base, the majority of thermals are lost through inaccurate flying. An admission of this fact will help to develop better thermal soaring technique and to prevent that "oh well, it wasn't really worth trying for", attitude which marks the poor soaring pilot. The excuse seems convincing because the thermal is seldom found again once contact has been lost. It should be remembered that the chances of finding a lost thermal, particularly low down, are very remote even if the approximate location is known.

A comparatively inefficient glider with a low normal flying speed can often outclimb the high performance sailplanes with their higher speed and consequent larger turning radius. This is because the slower glider is able to fly in the narrow core of very strong lift without using excessive angles of bank. However, the high performance craft has a greater gliding range and, therefore, has a greater chance of finding a thermal in the first place and needs fewer thermals to cover a certain distance.

Thermals are often produced at fairly regular intervals from a definite source on the ground, and when this occurs it is possible to gain height in one thermal and then fly up wind to pick up the next of the series. In windy weather it may be necessary to do this several times before sufficient height is gained to glide to the next good thermal source. In these conditions the clouds may form into definite cloud streets so that, once height has been gained, rapid progress can be made along the line of clouds without losing height for many miles. Good progress can be made across wind on days with parallel cloud streets by gaining height along one street before hopping across to the next one. The air between the cloud streets is usually descending and should be crossed as quickly as possible.

The beginner is advised to use these simple methods of thermalling rather than to attempt to understand which region of the thermal he is in and how his technique should be modified. In any case, the structure of the thermal described in Figure 49 is usually distorted by wind shear, etc., and it can only help to explain one of the forms of lift found while thermal soaring.

SUMMARY OF POINTS ON THERMAL SOARING TECHNIQUE

a. It is important to have a good launch; height above 600 feet is valuable on a flat site.

b. Search systematically up wind unless there is a definite indication of lift elsewhere.

c. During the search do not circle unless in lift.

d. Immediately lift is found, turn steeply and accurately.

e. Assess the position of the best lift and centre on it.

f. Concentrate on accurate turning and good look-out.

g. Do not climb up close to large cumulus clouds unless prepared and intending to enter them.

h. Watch the position of the airfield and, unless flying across country, turn back while within easy gliding range. Do not lose sight of the field.

CHAPTER 21

HILL SOARING

Hill lift—The advantages and disadvantages of sites at the top and bottom of the hill—Special rules for hill soaring—Using the hill lift efficiently—Using thermals—Landing at the top and bottom of the hill—Reaching the lift in adverse conditions—Down wind landings

When wind blows over a hill or similar obstruction, the air for a considerable height above it is deflected upwards and can be used by a glider. If the hill is small or the wind is light, this lift may only be sufficient to delay the descent. In better conditions the lift may be sufficient to support the glider up to two or three times the height of the hill. Provided that the wind keeps blowing in the right direction, there is no limit to the duration of soaring flight in this kind of lift. Naturally, the height, shape and length of the hill have a great influence on the strength and area of the lift. (Fig. 58.)

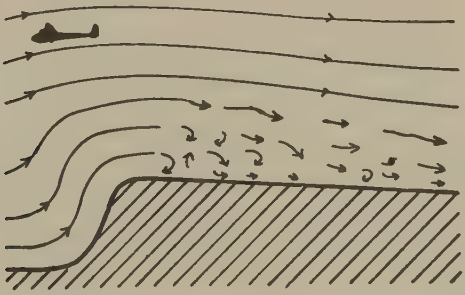


Fig. 58. The airflow over a hill showing the turbulent 'curl over'.

The wind meeting the hill will try to avoid flowing directly over it and will spill round the ends of the hill so that the lift there will be poor. A long ridge of hills is, therefore, much better for soaring than a short or isolated hill of the same height. The lift may also be spoiled if the ridge is in the lee of other hills. An isolated hill allows the wind to flow around it so that the lift is strongest behind the hill where the diverted airflow meets again. This is an example of one of the rather unexpected things which have been found on gliding flights.

Provided that the shape of the hill is reasonably smooth, the best lift will be found over or in front of the steepest slope. A cliff will give good lift but there is often an area of turbulent air close to the face where the air piles against the steep obstruction. This results in the main area of the lift near the ground being well in front of the cliff face as the false hill of air close to the cliff acts as the slope with the main air stream flowing over it. Also the surface of the hill can seriously affect the strength of the lift, particularly at low altitudes. If the slope and foot of the hill are wooded or broken ground, the lower layers of air will be retarded and made turbulent so that, although the lift may be strong at height, the lift near the hill-side may be poor and patchy resulting in a forced landing if the glider gets low.

The lift is stronger and extends higher on days when the air is unstable. Also, in some circumstances the hill may produce standing waves which make it possible to climb many times higher than in normal hill lift. It seems to be very difficult to predict the strength of the lift for a particular day since the hill lift is usually helped by a certain amount of thermal activity, and is affected considerably by the exact direction and strength of the wind above the hill which cannot easily be measured from the ground.

The direction and strength of the wind is the greatest factor affecting the soaring conditions. Good soaring is usually only possible when there is adequate wind blowing within about 30–40 deg of a direction perpendicular to the line of the ridge. However, if the hill has spurs and indentations, it is often possible to soar a very limited part of the hill wherever there is a long enough face more or less into wind, or to fly to and fro from one spur to the next.

Most of the recognized soaring sites in Great Britain have ridges which face the prevailing westerly winds and can be used on many days of the year. A ridge which does not face a suitable direction may appear to be a perfect hill soaring site, but is of little use if the wind only blows in the right direction once or twice a year.

The take off and landing area may be either at the top or the bottom of the hill. Ideally, suitable fields should be available in both positions so that launches can be made from the top and emergency landings at the bottom without risk of damage. (Fig. 59.)

The greatest disadvantage of the site on top of the ridge is that when the wind is strong and, therefore, ideal for soaring, there is likely to be an area of strong turbulence and very high rates of sink on the approach and landing. This makes it less suitable for training.

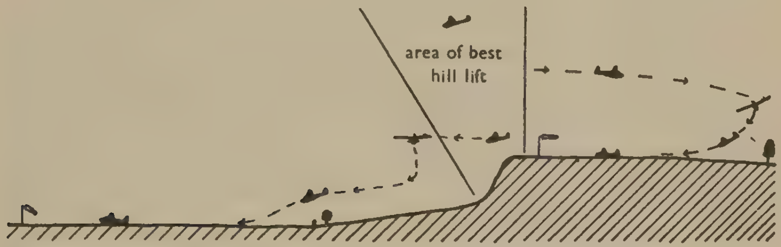


Fig. 59. Landings on hill sites.

In marginal conditions, the site at the bottom has a distinct advantage, as soaring can continue below the top of the hill and still end with a normal landing on the site. Provided that the wind is on the hill, there will be very little turbulence during landing and take off, although if the field is very close to the hill-side, it may be difficult to lose height for the approach.

Good hill soaring conditions encourage overcrowding and there is always a risk of collision if a good look-out is not maintained by all the pilots all the time. As many as twenty gliders may be using a comparatively shallow layer of rising air in front of the hill, and it is essential that good flying discipline is maintained. Certain special rules for hill soaring help to reduce the chance of an accident and these must be rigidly adhered to. Most club rules state that:

All turns on the ridge must be started by turning out *away* from the hill-side and a glider must not circle in the vicinity of other machines near the hill.

When overtaking along the ridge, the glider *overtaking* must pass *between* the other glider and the hill so that if the other starts a turn there is no danger of a collision. This is an exception to the normal rules of the air which state that the overtaking aircraft should pass to the right of the other aircraft.

Gliders overtaking or meeting at or near the same height must avoid passing directly over each other.

TECHNIQUE

After the launch, the glider is flown into a position in front of the brow of the hill and is moved along the ridge by turning slightly out of wind so that a gradual movement along the ridge is obtained without being blown beyond the top of the hill-side. (Fig. 60.) In good conditions it is generally possible to maintain a height of one or two times the height of the hill and the rate of climb at hill-top height will be good but will gradually fall off until only level flight is possible.

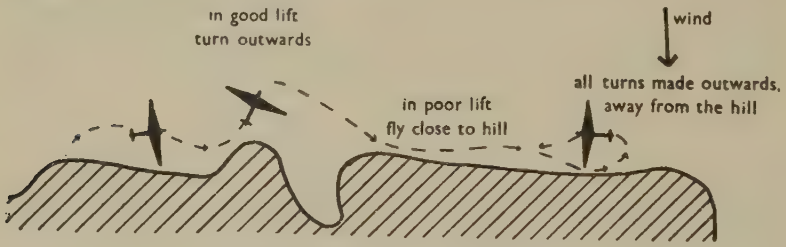


Fig. 60. Moving along the ridge.

The position of best lift in relation to the hill-side varies considerably. Only constant experiment will show whether it is better to keep almost vertically above the hill-top or fly well forward. Similarly, the strength of the lift varies considerably along the ridge, particularly if the hill-side is broken and has spurs or gullies in it. The wind direction will largely determine the places to expect the best lift. If the wind is not at right angles to the main line of the ridge, the side of a spur facing directly into the wind will often provide the best lift.

It is difficult to determine if good soaring conditions are the result of good hill lift or whether they are a combination of thermal and hill lift. Even on the coldest day thermals may form. If the conditions are thermic, lift will be strong in the thermals but often very weak at other times. In these conditions it is common to soar for long periods well above normal ridge soaring heights for the strength of wind, and then shortly afterwards to find insufficient lift to soar at all.

Except in very high winds, ridge lift remains comparatively consistent in relation to the contours of the hill and does not provide high rates of ascent unless the glider is close to the hill-side. Thermal lift encountered when ridge soaring is generally strong, inconsistent, and remains active for a short time but extends to greater heights.

After a pilot has gained some experience of ridge soaring and the "C" certificate soaring test has been successfully passed, the limitations of ridge lift flying should be realized. Since the hill lift reaches only a very limited height, it is not much use except for duration flights. Therefore, the hill lift should be considered solely as a means of extending the search for thermals or waves. Once a strong thermal has been found, a climb can usually be made to several times the height of gliders hill soaring. Even if it is intended to carry out local flying it is an obvious advantage to be able to fly from cloud to cloud instead of up and down the hill-side amongst other gliders, where a slight change of wind may result in a landing at the bottom of the hill.

An experienced soaring pilot would always seek advice from the local instructors or club members before flying from a strange site, and no club of repute would allow a stranger to the site to fly their aircraft without at least a familiarization flight to indicate emergency landing fields, etc. Certainly an inexperienced pilot would be ill advised to fly from a strange hill site without at least obtaining a careful briefing. It costs nothing to ask for advice and most people appreciate being asked for it, but it is too late to ask after an accident when the damage is done.

Generally speaking, it is unwise to attempt to circle in thermal lift on the hill when within 500 feet of the hill-side. If there are other gliders on the ridge, circling upsets the normal routine and increases the risk of collision. Any soaring near the hill-side should, therefore, be in the form of "beats" along the hill, with turns outwards away from the hill. When strong lift of either hill or thermal source is encountered, a turn should be made into wind. The speed should be reduced to that for minimum rate of sink, or to the speed necessary to maintain position without being blown backwards by the wind. In this way the glider can be kept in the strong area of lift until no more height can be gained, before turning again and proceeding to another part of the ridge. If the wind is not strong enough to allow the glider to remain stationary while it is at its best speed for minimum sink, a very short beat or S turn can be made from side to side in order to centre on the best lift. Often, the feature on the ground creating the lift can be seen and the glider can be manoeuvred accordingly. The lift from a small spur can be soared effectively in this way.

If the lift is thermic, close to the hill-side the same technique of flying to and fro in it can be used. As height is gained, it is wise to work forward away from the hill so that once a safe height is reached, normal thermal soaring turns can be made without risk of turning too close to the hill-side or upsetting the traffic patterns. (Fig. 61.) The thermals can sometimes be traced to particular villages, factories or other sources of heating, and these often act as continuous thermal sources throughout the day, giving an almost constant boost to the hill lift. If these sources are well up wind, local variations in wind direction cause the position of the lift to move to and fro. When the source is smoking, these changes may be seen by the change in the smoke. If a series of strong thermals are found at approximately the same place on the ridge but only last for a few moments, they may be from a fixed source but be moving along the ridge because of

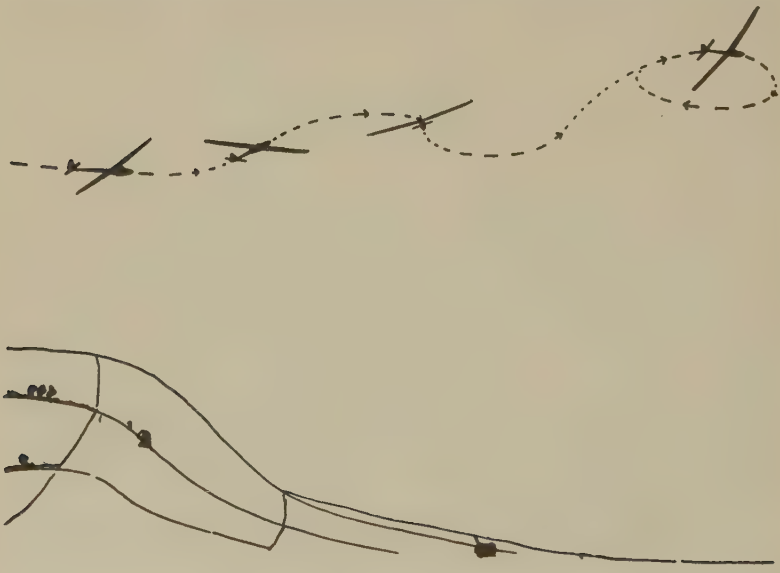


Fig. 61. Using thermals by making a series of S turns until well clear of the hill-side and other gliders before circling.

wind changes. The problem is then to tell to which side the lift has moved. If the glider is flown so that it creeps slowly along the hill across the thermal instead of directly into wind, when the lift decreases it is reasonable to assume that the area has been passed through, and a turn can be made with a very good chance of running into the lift again in its new position farther along the ridge. In this way there is a better chance of staying in the thermal lift than by either circling, or steering straight into wind and guessing which direction to look when the lift disappears. On unstable, thermic days there are areas of turbulence and rapidly sinking air reaching 10–20 feet per second, and these often completely obliterate the hill lift for short periods in spite of a reasonable wind. It is, therefore, necessary to be very alert all the time to get out of such areas before too much height is lost. Ten seconds of flight in sinking air can lose up to 200 feet of height, and a turn or even delay in taking action may result in so much height being lost that a landing at the bottom of the hill may be necessary. If an abnormally high rate of sink is encountered, it is best to lower the nose of the glider *immediately* to gain speed, even apparently at the expense of height, so that the area of sink is flown through as quickly as possible. At the same time the glider should be turned so that the beat along the ridge is continued. Never attempt to change the direction of "beat" while in a high rate of sink near the ground. as it takes time to turn and considerable height can be lost by staying in the sinking air. When conditions are very marginal, be prepared to reverse the "beat" whenever any lift is found and the glider is nearing the end of the "beat". This will decrease the chance of having to make the turn at the extreme end of the hill while losing height.

As height is lost, it is necessary to fly closer to the hill-side to find the best lift. The lift near the ground is often turbulent, and within about 300 feet of the hill-side care must be taken to fly at a speed which gives safe handling in these conditions and not normal gliding speed for the minimum rate of sink. Failure to observe this precaution is a common cause of loss of control when soaring in marginal conditions. It is particularly tempting for an inexperienced pilot to try to keep the glider up by raising the nose as the ground gets uncomfortably close, and this error will result in stalling without height for recovery. If the glider is in the correct position in relation to the hill-side, and is being flown at the correct speed, a further loss of height shows that the conditions are unsoarable and a landing should be made. A planned forced landing in a field at the bottom need never damage the glider, whereas a hill-side arrival or unpremeditated landing at the last moment may easily result in serious damage.

Once the glider comes below the level of the hill-top, the possibility of a landing at the bottom must always be considered. There is bound to be a certain amount of lift from the hill even if it is only sufficient to delay the sink of the glider. It is, therefore, possible to cruise for some distance along the face of the hill to the most suitable forced landing field or to a part of the ridge where there are suitable fields below. The flight can then be continued in the hope of the lift improving, with the intention of carrying out a landing in the selected field if any more height is lost.

Landing in a field of suitable size below the hill presents few difficulties. Like any landing away from base, the altimeter should be ignored so that any difference in height from take-off point cannot possibly cause confusion. At the bottom of the hill it is usual to find that the wind is much lighter and if this is allowed for, a landing into or across wind will be straightforward provided that the decision to land is made in plenty of time.

The majority of gliding sites are, unfortunately, at the top of the hill. There is nearly always an area of extreme turbulence down wind of the hill-top and this necessitates care when approaching to land. The airflow is unable to follow the sharp change in curvature of the ground and breaks away into turbulent vortices in the same way as the airflow over a stalled aerofoil. This turbulence may extend for more than a mile behind the hill but is particularly violent close behind the crest. Here the air may even be travelling against the prevailing wind and have large changes in speed and direction within a short distance. It is, therefore, necessary to approach with a good margin of flying speed so that there is no possibility of the glider being stalled, or control being lost, near the ground.

The minimum height at which to leave the hill lift to return to the site for landing depends on the nearness of the field to the hill-top, but it is generally most unwise to leave at less than 300 feet above the height of the hill unless the conditions are known to be smooth. Even then, if turbulent conditions are encountered it will be necessary to turn in to land without delay or there may not be sufficient height to complete the final turn safely.

Nearly every well-known site has particular areas to be avoided and it is wise to take advice from the "locals" on how and where to approach and land. When a ridge wind is blowing, it is not safe to fly beyond the down-wind boundary of the field even if surplus height is in hand. This ensures that even if sinking and turbulent air is met, there can be no possibility of falling short on to some obstructions on the boundary. This "clutching hand" effect behind a hill in windy conditions has to be experienced to be believed and most clubs have very rigid rules to prevent undershoot accidents through going beyond the boundary.

A landing at the top of the hill away from the launching site is inadvisable unless it is planned in plenty of time. As soon as the glider is flown behind the top of the hill, the "curl over" effect may result in very rapid loss of height leaving very little time for the choice of a suitable landing area, and the turbulence may make a low turn dangerous. Since it is necessary to leave the hill lift at several hundred feet above hill-top level when landing at the top, the conditions have to be much better to allow soaring to continue than when the landing area is below the hill. It is still very essential to have suitable fields in which to land in emergency because it is possible for conditions to change so quickly that it may be impractical to land at the site.

It is possible to have high winds blowing but for the hill to be unsoarable. This is generally caused by the normal hill lift being deadened by the down current of a lee wave or by turbulence from another hill up wind of the site. A slight undetectable change in wind speed will shift the position of the wave, and normal hill lift may return immediately. While the wave interferes with the hill lift, it is probable that the normal lift becomes restricted to a very shallow layer close to the hill-side which is too thin to soar in safety.

Where the hill is high, the wind in the valley may be very light so that although the wind on the hill-top appears strong enough there may be very little lift, particularly below the level of the hill-top. The first flight on any particular day is usually rather unpredictable, and the pilot should try to keep within easy gliding distance of the field and to explore the ridge gradually to see where the lift is dependable.

The technique of hill soaring can be summarized in the following points:

The best lift is found in front of the crest of the hill, the exact position depending on the slope and the conditions at the time of the flight.

The glider should be flown in long "beats" along the ridge making all turns outwards, away from the hill. When flying in rising air, speed should be that for minimum rate of sink or as necessary to prevent drifting with the wind; in sinking air, speed should be increased to progress along the ridge in search of better conditions. If high rates of descent are encountered, increase speed immediately for a few moments and turn along the hill.

Within 500 feet of the hill-side (or the height laid down by the local regulations) no thermal turns should be made. Any thermal turns should commence with a turn away from the ridge during which a good look-out must be kept for other gliders. If good lift is encountered, speed should be reduced and a turn made into wind away from the hill. In sinking air, turn so as to drift closer to the hill-side back into the hill lift.

At low altitudes it is necessary to fly close to the hill-side to stay in lift.

Select suitable fields for emergency landings immediately after being launched.

If the landing area is on the top of the hill, return to a position close to the landing area if conditions become at all uncertain, and turn in at 300 feet to land (or the height laid down locally).

Do not go behind the leeward boundary and use plenty of speed on the approach.

Decide on a minimum height for turning in to land at the top, and prepare to go to the bottom and land in a field if you get below that height. Select the most suitable field within easy reach, remembering that a safe landing is far more important than an easy retrieve.

If height cannot be maintained below the hill-top when flying at a speed above that for minimum sink, the decision should be made to land right away.

Throughout soaring flight watch the wind and weather and try to anticipate changes in conditions. The passing of a large cumulus cloud or shower will change the wind velocity and upset the hill lift.

Always fly in a position from which, if height is lost rapidly, a landing at the bottom is possible. It is easy to reach the hill from too far out in front but not from too far back.

It is seldom worth working hard to gain an extra 100 feet in hill-lift when there is any possibility of thermal activity.

Safety in flight on a crowded ridge depends on every individual pilot keeping a careful look-out all the time and obeying the rules of the air. Particular vigilance is necessary when there are only a few other aircraft flying and a look-out seems less important.

Be prepared for a landing away by knowing the most suitable fields for landing at the bottom of the hill. If conditions deteriorate and it is impossible to get back to the landing ground, don't be too proud to make the decision early to land at the bottom.

REACHING THE HILL LIFT IN ADVERSE CONDITIONS

Where the launching site is down wind of the ridge, it may be difficult to reach the area of lift in high winds. Since the wind speed is much stronger at circuit height than at ground level, the glider will make little progress at normal flying speeds. Furthermore, it is most probable that turbulence and sinking air may be met on the way because of the "curl over" effect just behind the hill.

In practice the winch driver can help by winching the glider as near overhead as possible. On release, the glider should fly at the best speed for penetration and continue at this speed till the hill lift is encountered or the attempt to reach the hill is abandoned. In this case, the extra speed can be converted into height while turning to return to the airfield. On sites where the launching area is some distance behind the hill-top, it is often only possible to reach the site by using the right procedure. Most unsuccessful attempts to reach the lift are caused by either poor winching and launch technique; not flying fast enough; or slowing down or changing speed several times on the way out.

On a site some distance behind the hill-top, it is sometimes possible to reach the landing ground by making a down-wind landing when there is not enough height for a normal circuit.

It is always very tempting to take a risk in order to avoid the embarrassment of a landing in a field but this consideration should never be allowed to influence the decision. Even very slight damage to a glider will put it out of action for much longer than the time taken to retrieve it from a field and even a minor incident may result in costly repairs.

Compare a landing into wind with that of a down wind landing when the wind strength is 20 m.p.h. (Fig. 62.) The touch-down speed of a Skylark would be about 15 m.p.h. into wind and 55 m.p.h. down wind. (Assuming an airspeed of 35 m.p.h. at touch-down in each case.) The glide path relative to the ground will be very flat when gliding down wind which will make a landing in a small field bounded by a hedge or trees very difficult if not impossible. (With full air brake in this case the angle of the glide path would be almost 20 : 1.) Furthermore, not only is the landing speed increased, but it will not be possible to maintain control all the time after the touch-down. As the glider slows down after landing, at a ground speed of 20 m.p.h. there will be no airflow over the controls because of the following wind, and the pilot will be powerless to prevent a wing tip from touching the ground. This may swing the glider round so violently that the skid is ripped off and both the bottom of the fuselage and the wing tip are damaged. If a down wind landing is inevitable, therefore, care should be taken to keep the wings exactly level and when possible the approach and landing should be made exactly down wind. It is vital to cross the boundary of the field as low as possible without any excess airspeed.

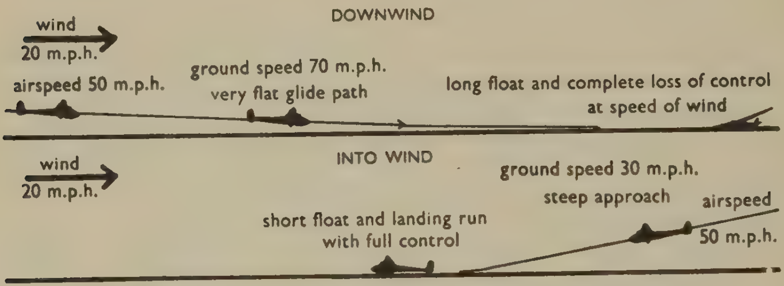


Fig. 62. A comparison between landing into and down wind.

When the risks of a down wind landing in a strong wind are compared with the inconvenience of retrieving the glider from a field outside the site, there is seldom any doubt as to the correct decision to make.

CHAPTER 22

WAVE SOARING

Lee waves—Lenticular clouds—Using wave lift—Future possibilities

IN certain atmospheric conditions the airflow over hills or mountains forms into wave-shaped disturbances which continue up to great heights and are propagated for long distances to the lee of the original source.

A standing wave can be considered as an example of hill lift in which the deflection of the airflow over the hill is transmitted from layer to layer of the air, to heights of eighteen to twenty times the hill height and sometimes possibly more. If the wind speed is sufficient, the lift will enable the glider to climb to great heights provided it is flown in the correct position in front of the crest of the wave. In high winds, rates of climb of 10–15 feet per second are common together with similar high rates of descent in the corresponding downward part of the wave. The airstream behind the hill will be affected, and a series of "lee" waves will form continuing for great distances down wind of the original obstruction and gradually diminishing in strength. (Fig. 63.) The distance between the wave crests (i.e. the wave length) depends on the wind speed, and the size of the obstruction, and the atmospheric conditions at the time. In light winds, the

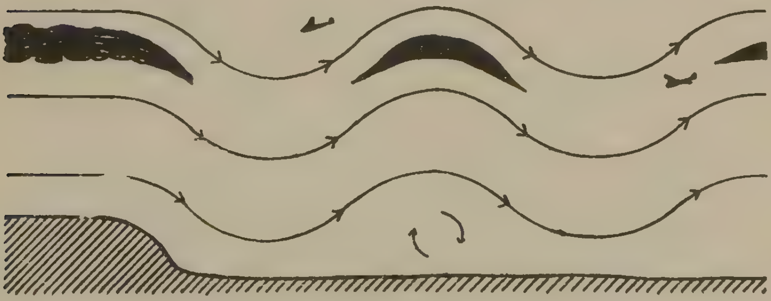


Fig. 63. Waves in the lee of a hill.

wave length may be so short that the formation of the wave is easily upset by any slight thermal activity or disturbance caused by another hill or obstruction. It is possible for thermal activity to exist amongst a wave formation provided that the thermal is small in comparison with the size of the wave. If the air is generally unstable, however, no wave will occur.

Visible evidence that wave conditions exist is very limited unless the air is moist enough to form cloud. The clouds generally associated with wave formations are in the form of long strips or bars of cloud of more or less an eliptical or cigar shape, lying approximately at right angles to the wind, parallel with the hill, and remaining nearly stationary in spite of high winds. These clouds are known as lenticulars and may be low, medium or high cloud and are often notable for their smooth, silky outline. They mark the crests of the wave forms at the particular level at which cloud is forming, but the wave lift does not cease at the cloud level and often there are several sets of lenticulars at different levels.

If the air mass is very moist, the cloud will take up the wave pattern without any gaps between each crest. It is often difficult to realize that the lenticular clouds at low altitudes are, in fact, standing in a constant position, since the individual particles of cloud continuously condensing at the front edge are swept back at high speed. However, the edges of the cloud remain stationary relative to the ground. The cloud sweeping back from the crest of the wave reaches the rear edge and then dissolves instantly. Although the whole cloud remains stationary, the air passing through it may be moving at 40–50 m.p.h. and resemble the torrents of a waterfall.

Changes in wind speed result in a change in wave length, or the collapse of the system altogether. Several ranges of hills may help the formation of a wave pattern if they are suitably spaced. However, unless the wind strength is such that the wave length will fit the position of the hills, they may destroy the wave formation or result in unusual local soaring conditions on those hills.

In 1951 there was an interesting example of this at the Derby and Lancs Club site at Great Hucklow, where the National Gliding Contests were being held. Normal hill soaring was in progress and seven or eight sailplanes were soaring at about 700 feet above the hill. Soaring conditions were satisfactory with a wind of about 15 m.p.h. on the hill-top. Suddenly, without any warning, the hill lift was almost completely squashed by what must have been the down current of a wave. Four of the sailplanes were forced to land in fields at the bottom while the others were just able to reach the normal landing area on top of the hill. Although there had been no detectable change in wind speed or direction, and the windsock had remained straight out all the time, the cause was almost certainly a change of wave length in a wave pattern formed by hills some miles up wind, which resulted in this marked change in soaring conditions. About fifteen minutes later, normal soaring returned and wave conditions were found by a few of the competitors.

The discovery of lee waves has opened up great new possibilities for long distance cross-country flights. The high wind speeds generally associated with good wave soaring conditions result in very high ground speeds, and since heights of 15,000 feet have been reached in the vicinity of 1,000-feet hills, this opens up the fields of high altitude flights during the winter months when there is little chance of thermal soaring.

TECHNIQUE

The lift associated with wave conditions is in the form of comparatively large areas of rising air lying more or less parallel with the hill range causing it. It may not necessarily coincide with the normal hill lift although it may often be possible to fly from the hill lift into the wave. Both in front of and behind the area of lift is another similar area of sinking air, so that losing the area of rising air in the wave generally means a rapid descent. But the lift in the wave is generally abnormally smooth and strong, because of the stable and laminar type of airflow. The smooth airflow is a distinctive characteristic of wave conditions and has a marked effect on the handling of the glider. The normal slipstream noise during flight is considerably reduced—probably by the elimination of some of the turbulent airflow over the aircraft as a whole. Often the air is so smooth that no control movements are needed for minutes on end.

In good wave conditions the wind velocity is usually high and it is, therefore, important to head almost directly into wind and to fly fast enough to avoid drifting backwards out of the area of lift. As more height is gained, the wind is frequently stronger and may change in direction. It is easy to regain the lift after flying slightly too fast and getting into the sinking air ahead of the wave. It is then only a matter of reducing speed and drifting slowly back into the lift. However, if the glider is allowed to drift back too far, considerable height will be lost penetrating forward against the strong wind in the down current.

Lenticular clouds or thin patches of cloud in amongst the wave give a good indication of the position of the peaks and troughs of the waves. If the glider is flown to a position just up wind of the edge of the cloud, it is easy to keep station with it and climb using it as a marker. If the cloud base is low, it is unwise to climb above cloud unless it is well broken as, if the wave conditions fail, the gaps in the cloud may quickly close in leaving no alternative but a blind descent through cloud.

Another excellent way of plotting the area of lift so that the best position can be found is to fly in company with one or two other gliders. If one glider drifts back too far, the other continues to mark the area of lift and there can be no doubt which way to go.

Cross-country flying in wave conditions is still in its infancy, although both on the Continent and in the United States long distance flights have been carried out by means of wave lift.

If a wave is formed by one hill or ridge of hills on a particular day, other waves will be formed by other hills elsewhere. It is possible to climb up in one wave and fly down wind through successive lee waves, finally perhaps contacting a new series of waves from another hill to continue the flight for some hundreds of miles. If the flight is made at 10,000 feet or more a very high cruising speed can be obtained once the initial climb has been made.

The flight down wind through the down current of one wave into the next wave will involve considerable loss of height unless the correct speed is flown. It is reasonable to expect rates of sink as great or greater than the rate of climb obtained during the climb, and the speed for travelling the farthest distance for height lost can be obtained from the performance curve of the glider. (See page 125.)

As soon as the rate of descent falls, a turn into wind can be made and the glider allowed to drift back into the next area of lift for another climb. It is usual to find that after two or three waves the system begins to deteriorate until finally, as each crest is reached, it is only worth while to reduce speed in order to get the farthest distance possible.

It seems fairly certain that now wave flying is receiving more attention from glider and power pilots than ever before, cross-country flights of great distance will be made.

Already flights of 1,000 miles have been planned in the United States and heights of 45,000 feet have been obtained, using standard gliders equipped with oxygen. However, these flights rely on the wave formations set up by mountain ranges much higher than any we have in this country.

So far, the glider has proved to be the best means of investigating both waves and thermals, and nearly all the significant factual data about these movements in the atmosphere have been recorded by amateur glider pilots.

One of the attractions of gliding is that a pilot may be fortunate enough to discover some new phenomenon in the atmosphere which has not previously been recognized. For many years, wave lift was unidentified at gliding sites where wave flying is now commonplace. It is not inconceivable, therefore, that some other form of lift may yet be discovered by glider pilots in the future. At present very little detailed knowledge is available about waves, thermals, or thunderstorms, and the average pilot can help in this important study by recording his observations for the Meteorological Research workers.

An interesting discovery is that there can be travelling waves moving down wind instead of remaining stationary as with standing and lee waves. Waves of this kind can occur in "jet streams", the high speed streams of air which are encountered by high altitude aircraft. The possibility of being able to soar in the jet streams with wind speeds of 100–200 m.p.h. opens up a complete new field for distance flying. Whether the glider pilot will learn to use these moving waves remains to be seen, but their existence opens up tremendous possibilities of flights of thousands of miles at great heights.

The existence and strength of wave lift enabling flights to be made to 45,000 feet above a 12,000-feet range of mountains seems remarkable, but the real potentialities can be realized when these flights are compared with flights to 15,000 feet above mere hills of less than 1,000 feet. Given the equipment, much greater heights would appear to be obtainable when the soaring conditions are right.

CHAPTER 23

LANDING IN STRANGE FIELDS

Standards of skill and judgement for safe landings—Choosing a field: The wind direction; location; size; surface; slope—The approach and landing—Retrieving arrangements—Preparations for cross-country flights—Advice for first cross-country flights

CROSS-COUNTRY flying is not difficult, and in good conditions flights of over 100 miles can be made by comparatively inexperienced pilots on their first attempts.

The art of cross-country flying combines many skills. Soaring ability, practical meteorology, navigation and instrument flying all play a big part in enabling the pilot to fly his glider where he wants to go.

Inexperienced pilots often have little idea of the problems which they may have to meet if they are forced to land in difficult country. It is not sufficient that the pilot can soar. He should have a minimum of new problems and experiences to face on his first solo cross-country flight and he must have enough flying background to be able to extricate himself from any difficulty which might arise when landing in a strange field.

A good soaring flight can easily be spoilt by damaging the glider on landing. Every year several high performance sailplanes are badly damaged during landings in strange fields, for the sole reason that the pilots had left their choice of landing ground much too late. These accidents result in a great financial loss, which could easily be saved by observing a few simple rules. Even slight damage to a glider takes many hours of skilled work to repair and may prevent further flying for several days. A safe landing should be the foremost aim in mind for every flight. This can only be ensured if the landing area is carefully selected while still at sufficient height and if a definite decision to land is made in plenty of time. The exact height at which this decision must be made depends upon the type of country over which the flight is being made and on the experience of the pilot. Inability to find a really suitable field for a safe landing is proof that the decision has been left much too late. There are only three main causes of accidents to gliders landing in fields:

1. Those caused by selecting an inadequate field because of lack of time or height.
2. Those caused by poor piloting or judgement in failing to make a satisfactory approach and landing.
3. Minor accidents caused by running over hidden obstructions such as rabbit holes, etc, after landing.

In many accidents caused by poor flying technique or misjudgement, the selection of too small a landing area is a contributory factor. For if a reasonably large field is selected, the permissible margin of error in under- or over-shooting is much greater, and only a very serious error would result in an accident. Until the pilot has considerable experience at landing in fields, the largest good field should always be selected.

The mere fact that the choice of field has been left too late may tend to make an inexperienced pilot panic, with the result that he may make a hasty and misjudged decision. Once this has happened, the pilot will often fail to regain control of the situation, and then only luck can prevent a serious accident. The best insurance against panic is to see that the situation is never allowed to develop into an emergency. This needs a clear understanding of all the factors involved in landing in fields, and the use of a methodical plan to ensure a good approach. It also means basically sound training to develop a true sense of self-confidence and a sensible realization of the limitations of personal skill and judgement. This must be based on true standards; for example, the ability to land in a marked area on the gliding site even without the use of an altimeter, may give the impression that a safe landing could be carried out in a similar sized field, which is not necessarily so. This type of test seldom has any element of surprise or hazard and the direction of approach is invariably one which is used during normal flying.

If the altimeter is used all the time during training and subsequent flying, there is a tendency to rely on it for indicating the height for the final turn before landing. This is a bad practice because it discourages the pilot from relying implicitly upon his own judgement with the result that he may even doubt it when faced with a landing in a difficult field. Furthermore the instrument is always liable to error, and never reads correctly for a landing away from the take-off point.

Although it is not suggested that the altimeter should be deleted entirely, more confidence in self-judgement is developed when the instrument is partially blanked off so that heights below 300–400 feet cannot be read. Every approach must then be judged and errors in the instrument caused by sticking, differences in the height of the ground, and incorrect setting cause no difficulty. Quite often the pilot may subconsciously develop a tendency to compromise between relying on his own judgement and on the altimeter reading, with the result that he develops little confidence in either.

Before embarking on cross-country flights, the pilot must find out how far he can trust his own judgement by making landings in strange landing areas, e.g. in odd corners of the gliding site or suitable fields. These landings must be made without the help of the altimeter.

The ideal approach is one using about half air brake to land on the desired spot. An approach so high that full air brake is required all the way, may end as a disastrous overshoot should the surface wind prove a little lighter than was estimated.

In many parts of Great Britain, the average size of fields is too small to allow much error of judgement on landing. Over open country, the choice of fields should be made at about 1,500 feet so that there is no possibility of being caught low without a good field in mind. A landing in bad country should be avoided whenever possible by keeping high enough to glide to a better area or by diverting round it.

THE WIND DIRECTION

Wind direction and strength are vital factors to take into account when choosing a landing area and, for this reason, the pilot must be aware of the direction of the surface wind at all times. This may change completely during the course of a flight so that the pilot should take notice of any indications of wind which he may see as the flight progresses to avoid the need for a frantic search for them at the last moment. Near the coast the sea breeze effect may cause a complete change of wind direction.

Smoke is the best wind indicator as both direction and strength can be accurately assessed at a glance. (Smoke from moving trains or ships must not, of course, be used.) Flags, ripples on trees, corn, or large areas of water are also useful in windy weather and, when the glider is below 1,000 feet or so, it may be possible to check the wind by noticing the amount of drift when flying across wind.

Although the upper wind is seldom exactly the same direction as that on the surface, the direction of movement of the shadows of the clouds on the ground may give a general indication of the wind.

If the wind is strong, the search for a good field should be made by flying down wind since this enables the glider to cover the greatest distance and, therefore, gives the best choice of fields. Up wind, the choice of field will be limited to those almost below, and an isolated field must not be selected up wind unless there is ample height to reach it with height to spare even allowing for the most adverse down currents on the way. This is important, because until the pilot has had considerable experience of selecting fields from the air, it is probable that a closer look at the field may show some unexpected obstruction which will make a further choice necessary. There must be sufficient height and time to allow another field to be found and reached.

The landing should be made as near into wind as possible in the direction giving the best approach and landing run. This has the advantage of giving a steeper approach, lower landing speed and shorter landing, all most useful in a strange field. The difference in touch-down speed alone should discourage down wind landings which are out of the question except for landing up sloping ground. The surrounding countryside will also affect the local wind strength and probable up- or down-draughts must be taken into account. For example, if the field chosen lies in the lee of high trees or a hill, strong turbulence and wind gradient effect are likely near the ground in windy weather, but the surface wind may be quite light. Great care is needed to guard against these effects, particularly in windy weather.

LOCATION OF THE FIELD

The choice of field should *never* be influenced by the convenience of retrieving, since the inconvenience and expense of even slight damage by far exceeds that of carrying the glider across a few fields after landing. In this country, there are few areas of farm land from which a glider cannot be readily retrieved and the best choice is always the largest good landing area within easy gliding range.

Fields alongside main roads almost always have power or telephone wires along them which can be invisible from the air and greatly reduce the effective run of the field if they have to be crossed during the approach.

Fields adjoining rivers, lakes or flooded areas slope down towards the water and should be avoided when possible. Any slope which can be seen from over 500–1,000 feet is much too steep for a safe landing and flat-bottomed valleys often have irrigation ditches which are difficult to see from the air. Any area in the lee of hills should be avoided in anything but very light winds because of the turbulent conditions often prevailing there.

SIZE OF THE FIELD

The effective size of the field depends on its direction in relation to the wind and on the height of any obstructions on the approach.

Whenever possible, a path should be selected which avoids the need to approach over high trees or buildings, since this will give the longest effective run over the field. In most cases a slightly smaller field with a low fence gives a longer effective run than a large field which has tall obstructions on the approach. Besides this, an undershoot on the approach is disastrous if the boundary of the field has large solid obstructions.

The direction and the strength of the wind must also greatly influence the choice of landing run, and particularly in light winds a long landing run across wind is usually preferable to a shorter one directly into wind.

Any slope in the field has a most marked effect on the landing run and the landing must always be made up or across the slope regardless of wind direction.

With few exceptions, the best field is always one with a good flat surface and the largest effective landing run.

SURFACE OF THE FIELD

The surface of the field is important since even a good landing in rough ground or tall crops will cause serious damage to a glider.

The glider pilot must, therefore, be able to recognize the appearance of different crops and types of farm land from the air to avoid such major blunders as selecting deep unripe corn by mistake for grassland. At different times of the year, the appearance of the ground changes considerably and an elementary knowledge of farming is most useful in reaching a sound decision.

Every pilot should practise selecting suitable fields quickly from the air on local soaring flights, and then try to criticize the decision and find a better choice nearby. This is of even greater value if there is time to visit the field afterwards to see the size and surface of the field and to reconsider the approach selected from the air.

Grasslands are the best landing areas and can be readily recognized when there are livestock in the field or similar adjacent ones. Landings in fields with animals should be avoided whenever possible as it is difficult to defend the glider from their curiosity after landing and they may stampede and hurt themselves or the glider.

If the ground is under regular cultivation, it is unlikely to be too rough for a safe landing since otherwise it would be difficult to use mechanized ploughing, etc. However, it is important to land along the lines of the furrows or crops even if it means a cross-wind landing.

Young corn and other similar crops are scarcely damaged by a glider landing but no sympathy can be expected from the farmer if the crops are almost ripe. Although the landing itself may not cause much damage to the crop, considerable damage can be caused while derigging and moving the glider out, particularly by spectators who trample the field without a thought of the damage they do.

The glider is usually severely damaged by the drag of long corn on the wings and tail. The low position of the tailplane on most sailplanes results in it breaking away and, sometimes, snapping the rear of the fuselage. If one wing is low, it may catch the corn and wrench the wing badly.

The use of a Vee tailplane or butterfly tail and high or gull wings have the main advantage that they are less susceptible to damage on landing in crops.

In many parts of the country it is possible to fly from airfield to airfield so that a premature descent does not involve landing in a field. Abandoned airfields are, usually, good forced landing grounds, although the runways must be carefully examined before landing as they may be obstructed or broken up in places.

Golf links and race courses have other excellent landing areas and large playing fields can be guaranteed to be safe landing areas provided that they are deserted at the time. A single cricket or football field is too small for a safe landing in calm conditions.

SLOPE

One of the major factors which must be considered when choosing a field from the air is the slope of the ground.

A landing on sloping ground must always be up or across the slope, *never downhill.*

If the slope can be clearly seen from the air, it is too steep for a safe landing and a further choice of field should be made. It is surprisingly difficult to discern even steep slopes from directly above so that a little reasoned thinking may well avoid trouble. Look at the lie of the land nearby in order to see the general trend of the hills and valleys in the surrounding country.

Fields near rivers and lakes slope towards the water. Fields with darker green areas indicate water-logged or low lying ground and are usually sloping towards the darkened areas.

Although it is not recommended, gliders can be landed up quite steep slopes without damage provided that they do not slide down after landing. If this happens, the tailplane and rear of the fuselage may be seriously damaged by any obstruction unless the pilot is quick enough to get out and prevent the glider from running away.

Many gliders are fitted with a wheel brake operated when the air brakes are fully extended. This is sufficient to shorten the landing run considerably and also prevent the glider moving after landing. If the glider is fitted with a skid only, it will not slide unless the slope is very steep.

Even a slight downhill slope will make it almost impossible to make the glider touch down, and the glider will tend to roll on without losing speed. The pilot will almost certainly have to put one wing tip on to the ground to swing it so that it does not run into the far boundary of the field. This will break the glider. It is almost impossible to make a successful downhill landing, and even if a downwind landing is necessary, it is vital that the landing should be made up, or across any slope.

Extra speed is needed landing up a slope since the change in attitude is more pronounced and a heavy landing will result if the glider flies into the slope. Furthermore, there is likely to be pronounced turbulence and wind gradient effects in the lee of any slope.

It is difficult to say whether the pilot should attempt to jump out and hold the glider after landing on a slope. His weight in the cockpit may be all that is preventing the glider from running downhill. If the glider begins to slide, the wing should be put on the ground so that it will slew round across the slope, giving the pilot a chance to get out and grab the wing firmly.

If the wind direction is up the slope, the landing can be made across wind. This is not difficult, as an approach with the "into wind" wing down counters the crosswind effect and gives more clearance for the wing tip.

It is wise to avoid choosing fields at the top of hills. If the ground does slope, the glider may slide to the bottom.

THE APPROACH AND LANDING

It is difficult to give much advice on how to make foolproof approaches into small areas except to stress the need for planning. It is comparatively easy to arrive on the lee side of the field much too high and to fail to use up sufficient height before turning in to land, with a resultant risk of a serious overshoot.

The only practical difference between undershooting and overshooting is the speed at which the obstruction is hit. Undershooting, the glider hits at flying speed whereas, providing that it has touched down, the speed will be greatly reduced in an overshoot. In both cases the glider will probably be badly damaged and the pilot shaken.

Undershoot accidents are nearly always caused by underestimating the strength of the wind, or the turbulence if the field is in the lee of trees or hills. The wind strength can be assessed most accurately by making a comparatively long base leg instead of several short beats or S turns to use up height. Undershooting used to be a common cause of field landing accidents, but with modern gliders having a very flat gliding angle, undershooting is almost unknown.

In general, bad approaches occur through getting too close to allow enough adjustment of height with the air brakes to place the glider in the ideal position to turn in to land. S turns are more likely to result in poor positioning than a well-planned circuit type of approach. Naturally the pilot must be capable of making good landings with any setting of the air brakes, across wind, and from short approaches. In fact he should be a complete master of his aircraft before attempting cross-country flights.

A particular warning is given against the temptation of trying to continue to soar at too low an altitude, waiting for what appears to be a certain source of lift to produce a thermal. It is very easy to sit just down wind of a steel works or similar thermal source waiting for the delayed sink to change to a gain of height, and to leave the actual choice of field and the method of approach to the last few hundred feet. This is much too late for safety.

Once the decision has been made to land, the air brakes should be unlocked and any further lift should be ignored. It is particularly dangerous to attempt to soar in weak lift over the chosen field as it will upset the circuit planning and result in a poor approach.

It may also result in the glider drifting away from the field so that, if the lift fails, a new choice has to be made from a selection of poor fields.

The decision to land should be final and it is a good plan for the pilot to trim the glider a little nose-heavy, unlock the air brakes and to say to himself aloud: "I am now going to land."

In the case of inexperienced cross-country pilots, this should be done at about 1,000 feet.

It is easy to get into a bad position with too much height, down wind of the field, by circling and looking down at it. It is best to keep up wind and well to one side of the field, preferably several fields away. This makes it easier to look at the field and see any slope in the ground. Otherwise it is difficult to get a clear look at the field and to keep it in sight while getting into position for a good approach.

Once the choice of the approach path and circuit direction has been made, it is best to select certain features on the ground for the positions where it is planned to start the base leg and the final turn on to the approach. If the fields are of average size the base leg should be started at least two or three field lengths to one side of the landing area and the approach turn completed about one field length from the boundary of it. (Fig. 64.)

The tendency is always to get much too close to the field, particularly if the pilot is used to landing on an aerodrome or a large gliding site. Since the country surrounding the chosen landing area is usually unsuitable for a safe landing, the circuit and base leg must be made at a distance that will feel uncomfortably far away.

A similar position on the average gliding site would still be over the landing ground, and this may lead to the pilot keeping too close to the edge of the field instead of keeping well off to one side. Since the glider will glide about 600 yards for a loss of height of only 100 feet, a long cross-wind leg can be made quite safely and more time is then available to adjust the height by using the air brakes.

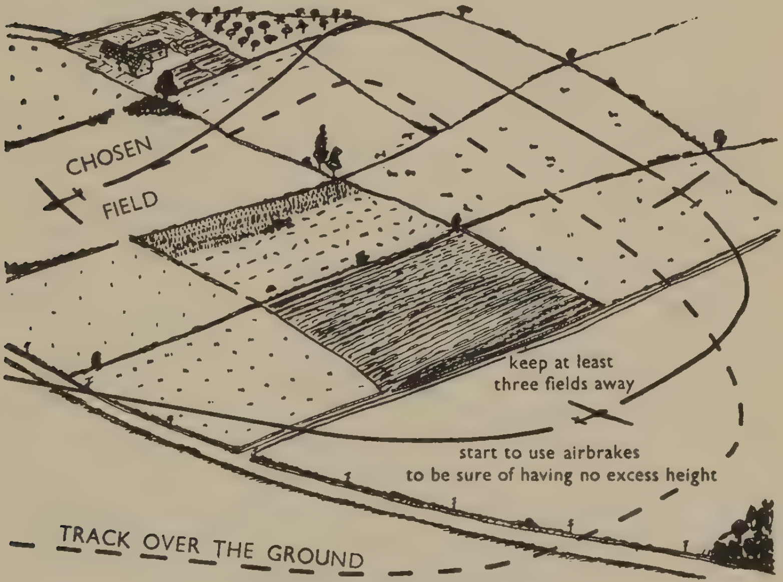


Fig. 64. Making a field landing.

The altimeter must be ignored as it will not read accurate heights above any field which is a different height from that of the take off. Heights below 500 feet are relatively easy to judge, and below about 200 feet a direct comparison can be made with the height of trees or buildings near the landing area. It is therefore best to use the air brakes to descend to the position chosen for the base leg and to make sure that it is reached without too much height to spare.

Flying at the normal approach speed, the air brakes should be used freely on the base leg so that the final turn can be completed without excess height and in a position to reach the landing area.

It will be immediately apparent if too much height is being used up and therefore the most likely error to make is that of arriving too high. It is important to realize that any errors of judgement of height will be far greater above 300 feet than near the ground. (Fig. 65.)

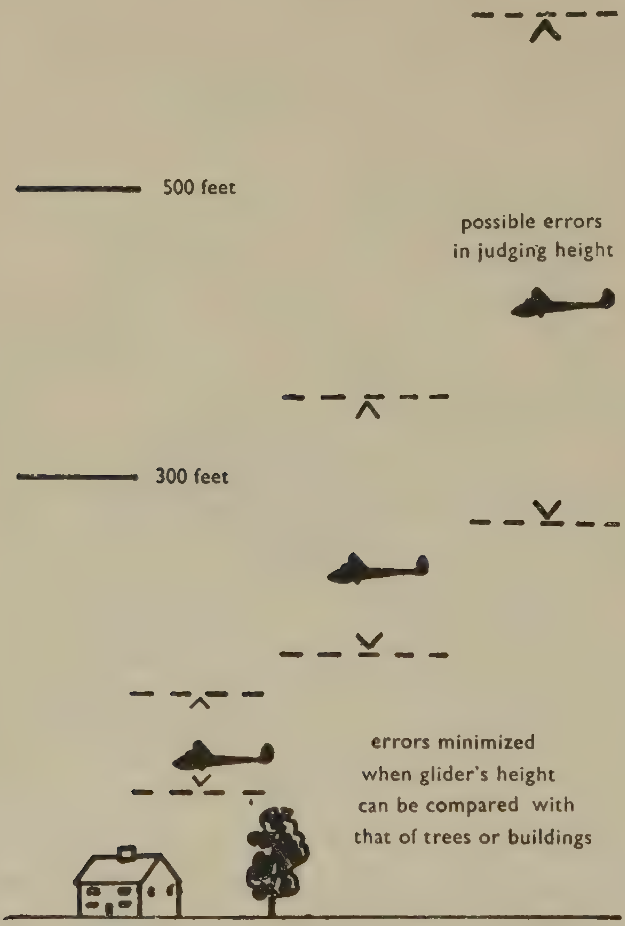


Fig. 65. Excessive height leads to larger errors of judgement.

The distance which the glider floats before touch-down is determined by the final approach speed. The approach should always be fast enough to allow a normal landing with full air brake, or a heavy landing will occur if full air brake has to be used unexpectedly at the la' moment. However, in calm conditions the approach speed should not be faster than absolutely necessary or the glider may float a long way and overshoot the landing area.

After the final turn, the approach can be regulated with the air brakes and, if the field is small, the boundary can be cleared by a small margin. Once it is certain that the boundary is going to be cleared safely, the pilot should concentrate on completing the landing well short of the far hedge.

The landing should be made with the tail well down so that the touch-down speed is as low as possible. Full air brake should be applied immediately, if it is not already in use, to shorten the landing run and to prevent bouncing after touch-down. If there is any possibility of running into the far boundary, the stick should be held hard forward to force the skid on to the ground, thus giving the maximum braking effect. The glider can be turned off to one side to lengthen the possible landing run and, if necessary, "ground looped" by putting the wing tip on to the ground and applying full rudder to swing the glider round. This may damage the wing tip and skid but that is preferable to running into a fence or wall at speed. Remember, skids and wheel brakes are ineffective on wet grass.

In the event of the pilot misjudging the approach badly and overshooting the landing area, the glider can be flown on to the ground and held down with a forward movement on the stick. However, this nose-down type of landing is not recommended for normal landings as it often results in broken main skids and damaged bulkheads. The next field ahead, if any, may be less expensive.

The glider should be sideslipped immediately there is the slightest possibility of overshooting, because once the final approach has been started, there will be very little time left to sideslip safely.

After landing, the pilot should first make sure that it is safe to get out of the glider. If the conditions are calm enough, he should get out and park the glider across wind, using the parachute as a temporary wing-tip weight. In strong winds, it is wiser for the pilot to wait for help, trusting that someone in the vicinity has seen him land. When help arrives, the glider should be moved to the corner of the field nearest the gate. If it is parked near the gate or fence, it is much easier to keep people out of the field and this will reduce the possibility of crops or fences being damaged. It will also be easier to prevent any animals or small boys from damaging the glider. Some clubs equip their gliders with a set of pickets to hold the glider down securely after landing. However, it is nearly always possible to collect stones or earth and fill the parachute carrying bag or even a flying suit with them to use as a wing-tip weight.

On NO account should the glider be left alone in a field with animals. They almost invariably cause damage by chewing or licking the fabric, or by trampling on the wing tips or tail. A responsible-looking individual can be asked to keep both animals and onlookers out of the field or away from the glider while the pilot makes his way to the nearest telephone.

It is usually possible to recruit several bystanders to assist in derigging the glider so that it is all ready to load into the trailer. They must be carefully briefed so that there is no risk of damage to the glider and, where possible, two persons should take the position usually held by one experienced club member.

If there is no prospect of a retrieve until the next day, the components should either be picketed down in the open, or if possible, moved to some kind of shelter for the night.

If the flight is likely to be used as a qualification for Silver "C" or a record claim, the barograph should not be unsealed. A landing certificate should be made out, signed by two witnesses and giving the following information:

Name of pilot.
Aircraft type and number.
Time and date of landing.
The exact location of the landing area.
The signature and addresses of two reliable witnesses.

The police are always most helpful, and it is wise to telephone them if a landing is made in a place where a large crowd of spectators are likely to gather. One policeman is a match for a hundred small boys and may save a lot of costly damage to the glider and to neighbouring property.

Most farmers are very tolerant of any minor damage which may be caused by the glider. (In practice, the landing seldom makes more than a slight wheel mark across the field and this is usually undetectable after a few days.)

If any damage is caused to private property, the pilot should remember that the glider is covered by insurance for third party risks and that it may prejudice any claim if he makes an admission of liability. However, it should be clearly appreciated that a glider pilot has no right to trespass by landing on a farmer's field and that it is in the interest of the whole gliding movement to maintain the happy relationship which at present exists in this country.

RETRIEVING ARRANGEMENTS

If possible, arrangements for the retrieve should be made before take off in order to reduce the time taken to collect the glider after landing. The most efficient way of retrieving the glider is to use two-way radio between the glider and the retrieving crew and for the trailer to attempt to keep up with the glider during the flight.

Radio is almost universal for competition flying and adds greatly to the fun. The retrieving team can keep in contact with their glider and share the excitement throughout the flight. When conditions are poor they can even help by pointing out promising looking clouds, other gliders, or even suitable fields for landing.

Without radio, the pilot telephones to either the starting point of the flight, or a town or aerodrome midway along the proposed track, giving details of where he has landed. The retrieving crew can set off as soon as the glider leaves the site, and they then make periodic telephone calls to see if the pilot has reported.

In most clubs, the trailer towing vehicle is often unable to leave the gliding site until the evening. In this case, it is easier to report the position of the landing back to the club by telephone and settle down for a long wait. Twenty miles per hour is a good average speed for a car towing a trailer, and unless careful map reference and directions for finding the glider are given, it may take some time to locate it, particularly in the dark.

The cost of retrieving must not be overlooked when planning a cross-country flight. For British roads, the road mileage for the retrieve can be estimated by multiplying the direct distance by 1.3.

For example: The road mileage for a flight of 52 air miles is $52 \times 1.3 = 70$ miles (approx.).

Some clubs encourage long distance flights by making all retrieving beyond 100 air miles distance, free of charge.

The cost of retrieving by air will, usually, be more expensive than by road but it is enjoyable and saves time.

The glider should carry the necessary tools for derigging so that the pilot can have it derigged and ready for loading by the time the trailer arrives. This is a great advantage as then it can be left without risk of being blown over and, if the vehicle and trailer break down on the way, the task of derigging will not have to be done in the dark.

The tools should include a hammer, pin punch and a pair of pliers, or any special tools needed for that type of glider.

PREPARATIONS FOR CROSS-COUNTRY FLIGHTS

It is a good idea to plan possible flights in various directions from the gliding site. Then, when a suitable day for cross-country flying occurs, it is much easier to choose a goal and very little last minute planning need be done. This is particularly necessary for attempts at Gold "C" distance flights which generally need to be started earlier in the morning than shorter flights.

It is worth making a list of the things which need to be done before take off so that there is no possibility of overlooking some vital item and spoiling a flight.

The following list will provide a basis for readers to add their individual "wants".

1. Obtain the best possible Meteorological forecast including the surface, 5,000-feet and 10,000-feet winds.

2. Refold maps. Check that they are clearly marked with Control Zones and Airways and with the minimum distance required for Silver or Gold "C" distance flights.

3. Consider possible goals and make out a flight plan taking into account the position of the airways, cities and bad areas for landings. For reference, note the Magnetic course, Magnetic track, wind direction and strength at various heights and the distance to the goal.

4. If the proposed flight is in a club glider or away from your home site, ask permission or give warning that you hope to make a cross-country flight.

5. Organize a retrieving crew and arrange communications, check that they have similar maps for pin-pointing the landing point.

6. Prepare sandwiches, chocolate, boiled sweets, and a thermos of hot drink if required.

7. Dress sensibly for the type of glider being flown: open cockpit

The German Ka6, probably the most widely used single-seater in the world, a popular club glider with an exceptional competition record

Photograph by Charles E. Brown

—all the clothes available however hot it is on the ground; enclosed cockpit—adequate clothes to keep warm and dry after landing.

8. Check the instruments for serviceability and log the altimeter settings when the altimeter is reading both zero and the airfield height above sea level for reference in flight.

9. Check that the tools required for derigging are in the glider.

10. Check the parachute, and adjust the harness until it is tight.

11. Reload, wind, check, and have the barograph sealed. Start it and stow it in the glider.

12. Move the glider to take-off point and stow the maps, etc, in the cockpit.

13. Go to the lavatory.

14. Write out a declaration of the proposed goal and give it to an official observer or photograph it in his presence.

15. Give any special instructions to the tug pilot if the launch is to be by aerotow.

ADVICE FOR FIRST CROSS-COUNTRY FLIGHTS

Never wait until the conditions are perfect before taking off. On a suitable day they improve rapidly.

For record or attempts for F.A.I. Certificates, the barograph record should show the point of launch clearly. Dive to mark the launch clearly if the glider is launched into lift.

Climb as high as possible before setting course. (At least 3,000 feet above the site.) Make sure the conditions ahead look reasonably good and if possible, aim for the next promising looking cloud more or less on track.

Note the times of release, setting course and each positive pinpoint.

Divert to keep in the areas of the best soaring conditions. If necessary, wait rather than fly across an area in the shadow of complete cloud cover.

Provided that the glider is fitted with suitable instruments and air brakes, take any opportunity to climb into small clouds, even if it is your first attempt at cloud flying. No height will be lost and, in all probability, valuable extra height and experience will be gained. Keep clear of cloud in Control Zones and Airways.

Check the surface wind whenever possible by noticing any indications from smoke, etc, *en route*.

Start looking for a suitable field for landing at any time you get below 2,000 feet.

Select a definite field at about 1,500 feet and look for lift within easy reach of it.

Pick the largest suitable field available. Check the surface, slope and the approaches. Avoid sloping ground. NEVER attempt a landing down hill.

Make a firm decision to go in and land at about 1,000 feet. Open the air brakes and make a definite descent to a position from which a long base leg and a straightforward approach can be made.

After landing, park the glider and, if possible, leave it in the care of a responsible person while telephoning the retrieving crew.

Give adequate information to make the retrieve easy. Whenever possible give the telephone number of the farm or place of landing for the retrieving team to contact in event of a breakdown.

Obtain a landing certificate giving time and place of landing, signed by two witnesses; and thank the farmer.

CHAPTER 24

THE INSTRUMENTS AND THEIR LIMITATIONS

The airspeed indicator—The altimeter—The variometer—Total Energy—The turn and slip indicator—The compass—The Cook compass—The artificial horizon—The barograph

The instruments generally fitted to gliders are the airspeed indicator, the altimeter, the variometer, the turn and slip indicator and the compass. Every pilot should know how they work and their principal limitations.

AIRSPEED INDICATOR (A.S.I.)

The A.S.I. is an air pressure gauge designed to measure the pressure developed by the forward movement of the aircraft.

This instrument really makes a comparison between the pressure built up in a forward-facing pitot tube or pressure head mounted out in the airstream at some convenient place on the aircraft, and the atmospheric or static pressure at the time. Both the pitot tube and static vents must be situated in positions where the influence of the shape of the fuselage or other parts of the aircraft is at a minimum, or large errors will occur. The pressure head may be an open tube facing forward on the nose or wing, or a hole in the centre of the nose. To avoid icing up, some form of electrical heating is necessary with the tube, whereas with the nose or "pot pitot" as it is known, the hole can be much larger, and the lead to the instrument arranged so that ice is unlikely to obstruct it.

In some open cockpit gliders, the air pressure in the cockpit is near enough to the true atmospheric pressure to use it as the static for the airspeed indicator. On most other gliders, the shape of the cockpit causes changes in the pressure at different speeds which would cause large errors in the instrument. It is, therefore, necessary to provide an accurate static pressure and this is usually done by a static head mounted with the pressure head, or by having a vent to some part of the skin of the aircraft where the air pressure in flight is unaffected by varying speeds.

It is an unfortunate fact that pitot tubes have an almost hypnotic attraction for human beings and, in particular, for small boys, who love to blow down them. This causes serious damage to the expanding capsule in the instrument so that either it is rendered completely useless, or reads 40–50 m.p.h. too high all the time. The "pot pitot" is difficult to blow down and almost "boy" proof.

When the glider is being stalled in order to check the A.S.I., the speed should be reduced at a rate of about 1 m.p.h. per second.

For the reader's benefit, speeds are given in this book in m.p.h., but a more usual unit today is the knot. 1 knot is slightly more than 1 m.p.h. (66 kts = 76 m.p.h.)

The airspeed indicator suffers various errors owing to variations in height and temperature and in the position and type at pitot head.

Height and temperature errors are the result of calibrating the instrument on the assumption that the atmosphere has standard properties at all heights, instead of allowing for variations of temperature and pressure with height.

These errors are of no importance to glider pilots during local flying but are of general interest to the pilot flying above about 8,000 feet. The A.S.I. under-reads at high altitudes because of the reduction in the density of the air with an increase in height. However, the indicated stalling speed and, therefore, the best indicated cruising speed remain the same although the true speed is higher. This increase is approximately 1.75 per cent of the indicated speed per 1,000 feet of height. The glider cruising at 10,000 feet has the advantage of an increase in cruising speed of 17½ per cent and this is a very welcome help on long flights. (This increase also results in an increase in the normal rate of sink of an equivalent amount since the gliding angle remains the same.)

Changes in temperature can also cause errors owing to the effect on the density of the air but these can be ignored except for test flying purposes or for special high altitude cross-countries.

Position errors are caused by the position and design of the pitot and static tubes and vary with each type of glider and installation.

It is important to realize that large errors can occur with a pot pitot when the glider is yawing. For example, in spins and side slips, the indicator needle usually moves back through the zero position to read a fictitious speed until the glider resumes normal flight.

The position errors should be taken into account when calculating the optimum cruising speeds for cross-country flying. If the performance curve used for these calculations is in "equivalent" airspeed, the corrections for position errors can be applied to give the corresponding "indicated" airspeed for use in flight.

If a change is made in the position or type of pitot or static heads, it is important to check whether the position errors have changed. Otherwise it is conceivable that the glider might be flown at a true speed above the maximum for which it has been designed although the indicated speed may not exceed the "Placard" speed in the cockpit.

It is interesting to note that the position error on a towing aircraft may be as much as 8 or 10 m.p.h. at low speeds because of the nose-up attitude of the tug. It is this position error which often accounts for the large difference in indicated speeds between the tug and glider.

Airspeed "Lag". If the airspeed indicator is serviceable, it has little lag in recording changes in speed. However, the "lag" in the airspeed is frequently referred to in gliding, and this really refers to the time taken for the glider or aircraft to change its speed following a change in attitude. When the attitude of the glider is changed, e.g. if the nose is lowered, the inertia of the glider makes it continue at the original speed for a short time before gradually gaining speed. Eventually, a steady speed is reached depending on the steepness of the attitude.

A further source of error may be leakage in the tubing and connexions between the pitot head and the instrument. These should be checked over periodically, and the tubing replaced if it shows signs of deterioration. A useful test for the system and instrument is to seal off the open end of the pressure head with a finger and rub the tube hard. The frictional heating expands the air inside the tube and operates the A.S.I. over the range normally used when gliding. On no account should blowing directly down the pitot tube be resorted to as this will cause damage.

THE ALTIMETER

The altimeter is a sensitive type of aneroid barometer calibrated to read heights in feet or metres. On the modern altimeter, the indication is given by clock-like hands. The large hand reads in hundreds of feet, one rotation indicating 1,000 feet. The smaller hand reads in thousands of feet, one rotation indicating 10,000 feet; and a very small pointer indicates tens of thousands of feet. This type of calibration enables the instrument to be read quickly and accurately down to the nearest 10 feet. However, a glider in flight does not provide enough vibration for the instrument to read absolutely accurately because of the friction in the lever system, etc. This friction can be overcome by gently tapping the instrument panel (NOT the instrument itself) but, since an exact indication of height is seldom necessary, it is better practice to allow for the instrument error of 50–100 feet during descents and to judge the height above the ground by eye for the approach and landing.

The altimeter can be set before take off to read either the height of the airfield above sea level for cross-country flights, or to zero feet for local flying. A setting of 1013.2 mbs. is standard in airways.

Quite serious errors can be caused during the course of a flight by changes in atmospheric pressure. These are particularly important if the flight is over a long distance as the pressure may change by 10 or 20 millibars making a difference in reading of hundreds of feet. If the altimeter is set before take off, it will not read correctly over ground of a different height and it is, therefore, worse than useless for making approaches into strange fields. In fact, it is unwise to get into the habit of using it below a height of about 300 feet where the pilot's judgement is more dependable at all times.

Like the A.S.I., errors are caused by both changes in temperature and static pressure errors. However, static pressure errors are so small that it is normal to leave the altimeter open to the cockpit pressure. This avoids any possibility of it becoming iced up or blocked in flight.

Most altimeters are calibrated on the assumption that the atmosphere has a regular reduction in temperature with height.

In practice the temperature varies considerably causing errors in the altimeter readings at height. These are seldom of importance or interest to the glider pilot except in the case of height record attempts.

THE VARIOMETER

The most important instrument carried in the glider on soaring flights is the variometer. This is a very sensitive rate of climb and descent indicator which enables the pilot to detect rising air and to find the position of the best "lift".

The operation of the variometer, like the altimeter, is dependent on the change of atmospheric pressure with height. The variometer, however, measures the rate of change of pressure as the glider gains or loses height. Most glider instruments consist of a flow meter which is connected to a thermos flask acting as a capacity.

As height is gained, air flows from the thermos through the instrument which measures the rate of flow and indicates it as a rate of climb. When height is lost the pressure inside the flask is less than the outside atmosphere and air flows through the instrument and into the flask. Obviously for low rates of climb and descent the amount of air involved is minute and it is surprising that it can be detected by mechanical means.

One of the earliest and simplest types still in widespread use today is the Cobb Slater or COSIM.

The principle of the instrument is adequately explained by Fig. 66. However, the actual detailed construction is of interest.

The indicators consist of small pistons of extremely light red and green plastic material. The tubes containing the indicators have a very accurately machined and polished parallel bore to ensure a good fit and have a small tapered keyway cut in one side of the bore to provide the variable leak. This keyway is widest at the top and tapers away to leave a smooth round bore at the bottom. As the indicator is raised by air flowing through the instrument, it allows air to leak through the keyway. The higher the position of the indicator, the greater the leak and the greater the flow of air required to maintain its position. At each end of the tubes is a small filter to prevent dust entering and spoiling the bore.

One of the best types of mechanical instruments is the vane type made by P.Z.L. and Horn. It consists of a cylindrical chamber with a very close-fitting vane mounted on jewelled bearings and centralized by means of a hair spring. (Fig. 66b.) The air flowing too or from the thermos is directed in a jet against the vane, deflecting it round and moving the indicator needle. Carefully shaped slots below the vane provide an escape for the air so that the position of the vane regulates the size of the outlet. The whole instrument is a masterpiece of precision and it is sensitive and has very little time lag. The circular dial and regular calibration make it particularly suitable for determining the best speeds to fly between thermals, since a movable, speed to fly ring can be mounted round the face of the instrument as in Figure 71b on page 244.

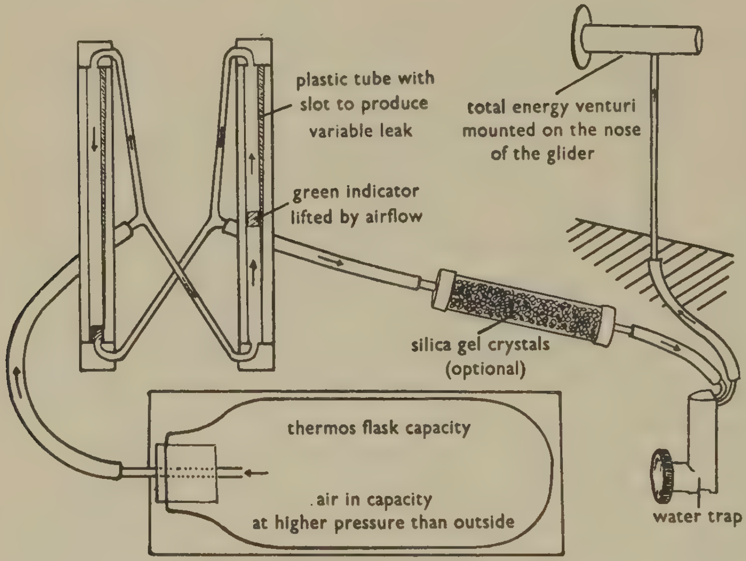


Fig. 66a. The Cosim variometer fitted with a total energy venturi showing the airflow during a climb. (Not to scale.)

Both the Cosim and the vane types are being superseded by electrically operated variometers because of their quicker response and better sensitivity. In these instruments the flow of air is detected by its cooling effect on thermistors. Changes in their resistance are amplified and shown on a sensitive meter. The time lag and inconsistencies associated with overcoming the friction of the vane or pellets are avoided and both very small and large rates of flow can be accurately measured.

The range of the instrument can be varied electrically to suit the strength of the lift by means of a switch changing the amplification. Furthermore, a simple attachment can be fitted to give audible indications of lift from a small loudspeaker. This is particularly valuable in difficult conditions near the ground or in a crowded thermal when it might be dangerous to concentrate on watching the instruments.

Electric variometers are very reliable and will operate for many days' flying on a small torch battery. However, the installation is more critical and a poor one may cause excessive fluctuations which can be very confusing. For example, these instruments should not be coupled direct with the same static source as the A.S.I. or changes in speed may cause false readings on the variometer as the capsule of the A.S.I. expands and contracts sending small pulses of air along the tube. If the static is left open to the cockpit, the tube should be shielded from draughts. Even then yawing and pitching movements of the glider may still cause errors because of the changes in cockpit pressure and it is, therefore, better to connect it to proper static vents.

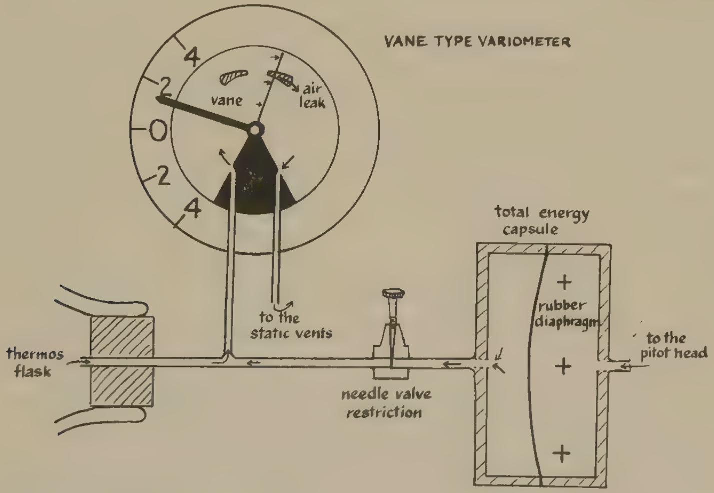


Fig. 66b. A vane type variometer installation with a total energy capsule.

TOTAL ENERGY

A variometer should enable the pilot to fly the glider into the strongest part of the lift. Inaccuracies in flight caused by the turbulent air or by poor piloting result in a change of airspeed and affect the readings on an ordinary variometer. If the nose of the glider is raised for a moment, the glider will tend to gain height as the speed decreases. This will be indicated as a reduced rate of sink or a gain of height and will be registered on the variometer. Similarly, if the nose of the glider is lowered the variometer will show an increase in the rate of descent. These indications of climb and descent can very easily be mistaken for a sign that the glider has flown into rising or sinking air. The false indication of climbing which is caused by a backward movement on the stick is known as "stick lift".

The total energy variometer is a variometer which is compensated to eliminate any apparent lift or sink caused by changes of airspeed.

Since it is usual to fly faster between thermals and to slow down as the lift is encountered, the normal variometer gives very misleading indications of strong lift as the speed is reduced. These can easily result in the pilot wasting time on non-existent or poor lift.

Any type of instrument can be converted to total energy by fitting a suitable capsule device, venturi, or blisters. The venturi or blisters are connected to the static side of the variometer. (Fig. 66a.)

In flight at a steady speed, the suction produced by the venturi is constant and the variometer, therefore, reads the normal rate of descent.

If the speed is increasing at any particular moment, the nose of the glider is lower than the normal position for steady flight at that speed. This results in the glider having a higher rate of descent than would normally occur at that speed in a steady glide. However, with the total energy variometer, the increase in speed also increases the suction at the venturi and this exactly compensates for the increased rate of descent caused by the changing speed. It follows that at any given moment while the speed is changing, the variometer reads as though the glider were flying steadily at the speed indicated at that moment.

It is, therefore, possible to assess the position of the lift even though the glider is being flown inaccurately or while slowing down after flying at speed through a downdraught.

The ordinary variometer indicates a rate of change of height, i.e. the change in potential energy of the glider. The venturi corrects for changes in speed or kinetic energy of the glider. The total energy variometer indicates the combination of changes in potential and kinetic energy.

Total energy capsules are fitted between the instrument and the pitot head and can be of various designs. The simplest, originated by George Burton, consists of a small plastic or metal chamber divided in the centre by a lightly stretched rubber diaphragm. (Fig. 66b.)

When the nose is lowered and the speed increases, the diaphragm is deflected by the increase in pressure from the pitot head. This forces more air through the instrument giving an additional rate of climb for a few moments. At a steady speed, the diaphragm remains stationary (though it may still be deflected) and therefore it has no effect. As the speed is reduced, the diaphragm relaxes and this reduces the flow through the instrument and cancels out the rate of climb resulting from the change in speed.

If the diaphragm becomes too slack, it will over-compensate and lowering the nose will result in an indication of climb. This is hopelessly confusing and it is better to have it under-compensating even if a little "stick lift" remains. Since the rubber gradually stretches and perishes, and a rupture would make both variometer and A.S.I. unserviceable, a metal alternative, though more expensive, will probably supersede this type.

Unfortunately, the airflow in a thermal has horizontal gradients or gusts, and the total energy variometer responds to any increase in speed by assuming that the nose has dropped. In this way horizontal gusts give false indications of lift or sink and these are often as much as 6 feet per second. This can be overcome by fitting a restriction in the tube from the pitot head. A restriction giving a time lag of 3 to 4 seconds will eliminate most effects of horizontal gusts which only last a few seconds without effecting the total energy correction for speed changes.

It is difficult to achieve accurate results in all conditions and, for this reason, most pilots use two variometers. Usually a vane type (P.Z.L. or Horn) with a speed to fly ring and total energy is used between thermals and an electric instrument with audio is used for centring in the lift. When more accurate total energy devices become readily available, a single electric variometer with total energy and audio will be all that is required.

Variometers are often calibrated in knots instead of feet per second or hundreds of feet per minute. Then if the A.S.I. is also in knots, the gliding angle can be assessed by dividing the estimated ground speed by the rate of descent (e.g. headwind 10 knots, speed 60 knots, rate of sink 2 knots . . . gliding angle is 60 − 10 ÷ 2 = 25 : 1). Conveniently 1 knot equals almost exactly 100 feet per minute so that if the height gained is timed for 30 seconds or a minute the rate of climb can be found without calculation (e.g. 550 feet gained in 1 minute is 5.5 knots).

Inaccuracies in either the variometer or the A.S.I. will lead to flying at inefficient speeds and even to making wrong decisions. To fly with confidence, these instruments should be recalibrated every year so that any errors are known and can be taken into account.

Since no two installations are identical, it is a greater advantage to practise regularly with the same aircraft and instruments.

THE TURN AND SLIP INDICATOR

The turn and slip indicator is the most important instrument for blind flying. It is fitted to aircraft as a standby to use when the limitations of pitch or roll for the artificial horizon have been exceeded. The turn and slip indicator is exceptionally reliable and does not become unusable even if its limitations are exceeded in flight, since it recovers immediately.

It consists of two instruments mounted in a single case: the rate of turn indicator, which is a gyroscopically operated indicator showing the direction and rate of turn, and the slip indicator which is a simple pendulum or similar device.

a. The Rate of Turn Indicator

This is operated by an electrically driven gyroscope mounted so that it can only tilt in the rolling plane, and having the axis of the rotor parallel to the lateral axis of the aircraft. Rolling movements of the gyro are controlled by a spring and damping system. When the aircraft changes direction, the yawing movement causes the gyro to precess and tilt against the tension in the spring, so that the angle of movement is proportional to the rate of turn. The indicating needle connected to the gyro gimbal registers against the scale showing the actual rate of turn. Adjustments can be made to the spring to calibrate the instrument so that a rate 1 turn is a turn of 450 deg per minute. Ordinary powered aircraft instruments are calibrated to indicate a rate 1 turn as a turn of 180 deg per minute and are unsuitable for gliding unless they are readjusted to reduce their sensitivity or are run at lower rotor speeds.

Turn indicators for gliders are driven by a battery-operated electric motor forming the rotor, and these are regulated to maintain a constant speed for a large variation in voltage of the battery. Ordinary dry batteries are sufficient power for many hours operation but care must be taken to check them on the ground to ensure that there is no possibility of the battery failing in use. Immediately after changing the batteries a test should be made to ensure that they have been connected correctly since reversed connexions result in reversed indications. When the instrument is switched on, swinging the glider to the left should make the needle show a movement to the left. The batteries should preferably be of a type fitted with terminals since there must be no chance of a poor connexion at any time.

Earlier types of instruments are operated by a gyro rotated by jets of air. The air is drawn into the instrument by suction from a venturi tube mounted in the airflow. This type of instrument has several disadvantages on gliders although it is used in many powered aircraft where the suction can be provided by an engine driven pump. Unless the venturi tube is large enough, the necessary airflow cannot be obtained at the low normal flying speeds of the glider. Furthermore, because of its size, the venturi causes high drag and may easily become iced up, rendering it useless just at the time when the turn indicator is absolutely vital.

Most of the faults occurring in the electrically operated turn indicator are caused by poor connexions, unsatisfactory switches and flat batteries. However, after a great deal of running the carbon brushes in the instrument may fail to make good contact on the commutator and cause inconsistent starting and running. Since the instrument must be completely dust free it should not be opened and tampered with except in dust-free conditions.

b. The Slip or Balance Indicator

The slip or balance indicator may consist of either a small pendulum geared to a pointer, or a steel ball mounted in a liquid-filled tube. (See Fig. 9 on p. 22.) When the aircraft is standing on the ground with the wings level, the needle or the ball should come to rest in the central position. In accurate straight flight or correctly balanced turns, it indicates no slip or skid, but whenever the flight is unbalanced, the needle or ball of the slip indicator shows a deviation from the central position, caused by the offset loading on the pendulum weight or ball. In a correctly balanced turn the pendulum or ball is held in position by the centrifugal force produced by the turn. Both types of indicators have their advantages. The pointer is probably easier to read at a glance since all the other instruments register with pointers, and the eye becomes accustomed to this form of indication. The ball in the tube is, however, an exceptionally simple and foolproof device which cannot stick or give trouble. The liquid, together with a slight bow in the tube damp out any tendency for the ball to oscillate excessively in turbulent conditions. In the pendulum type of instrument, a mechanical means of damping is used and, unless it is exactly right, small inaccuracies on flight may not be registered. For this reason it is not so popular on gliders.

The rate of turn indicator and slip or balance indicator are normally mounted in one instrument.

Errors in the indications of the Turn and Slip Indicator

An incorrect rate of turn will be indicated by the instrument if, for some reason, the speed of the gyro rotor is too high or low, although the indications will remain in the correct sense. If the battery driving the instrument is running down, the sound of the rotor revolving is noticeably different and the instrument will under-read the rate of turn. When this happens the pilot should use only a small rate of turn to prevent the true rate of turn becoming excessive, and he should seek clear air before the battery fails altogether.

During the recovery from "dives" or "spirals" any slight rate of turn is greatly exaggerated by the change of direction in the pull out from the dive. In this way, even a slight turn during a recovery from a dive will indicate as a high rate of turn. As soon as the loading is reduced again, the correct rate of turn will be shown.

THE COMPASS

The compass is an essential instrument for flying across country. Unfortunately, the normal aircraft type of compass has many limitations and errors which make it difficult to maintain an accurate course. Most inexperienced pilots greatly underestimate the difficulty of flying on a compass course.

The normal type of compass used in gliders is of the "wall" type and is fitted on to the instrument panel. It consists of one or more small bar magnets suspended in a liquid-filled container. Attached to the magnet system is a small drum engraved with the cardinal points of the compass and in divisions of 5 or 10 deg. These can be read through a glass window so that the reading of the scale against a line on the window gives an accurate indication of the magnetic heading of the aircraft. The liquid, which is usually alcohol, helps to damp out the oscillations of the compass.

Magnetic and True North

Magnetic North is some distance away from the geographical North Pole about which the earth rotates, so that the compass magnet does not point towards true north. A correction known as variation must be applied to any "true" heading measured on a map, to give the equivalent "magnetic" heading. Lines joining places with equal variation are marked on most maps so that the correct average variation for a particular flight can be ascertained. Owing to the continuously changing location of the earth's magnetic field, the variation marked on the map is subject to a slight yearly change.

The method of applying the correction can be easily remembered by the rhyme:

> Variation West—Magnetic Best (i.e. greater than True)
> Variation East—Magnetic Least.

For example, the variation for the London area is 8 deg west (1959) and is subject to a change of about eight minutes per year. Since it is impractical to fly to that degree of accuracy, 8 deg west would be a quite satisfactory correction.

Deviation

Deviation, another source of error in the aircraft compass, is caused by the magnetic influence of metal components in the aircraft itself or the electro-magnetic field set up by some electrical instruments. The compass should not be mounted close to these instruments or it may not maintain the correct reading when they are switched on.

Deviation varies according to the direction in which the aircraft is heading and can be reduced to less than 5 deg on any heading by a process known as swinging the compass. This is done by taking careful readings on the compass every 45 deg, and comparing them with the reading of a hand-held bearing compass outside the aircraft, so that the errors can be measured. The compass can then be adjusted by means of the corrector magnets in the instrument to reduce the overall error to a minimum. A card of compass deviations can then be made out listing the corrections to be applied to the magnetic readings in order to obtain the correct course to steer on the compass.

Deviation cards are however, seldom used in gliders although it is highly desirable to swing the compass and reduce the deviation to a minimum if cross-country flying is contemplated since, otherwise, errors of 15 deg or more may occur.

The process of arriving at the required course to steer on the compass can be summarized as follows:

1. Measure the angle of the track relative to the nearest meridian of Longitude or other line running true north and south on the map (example 000°(T)).
2. Apply the variation ($000^\circ + 8^\circ = 008^\circ$ (M)).
3. Apply the deviation if a deviation card is fitted to get the required course compass. ($008\text{(M)} + 4^\circ = 012^\circ$(C)) (where $+4^\circ$ is the correction for the deviation.)

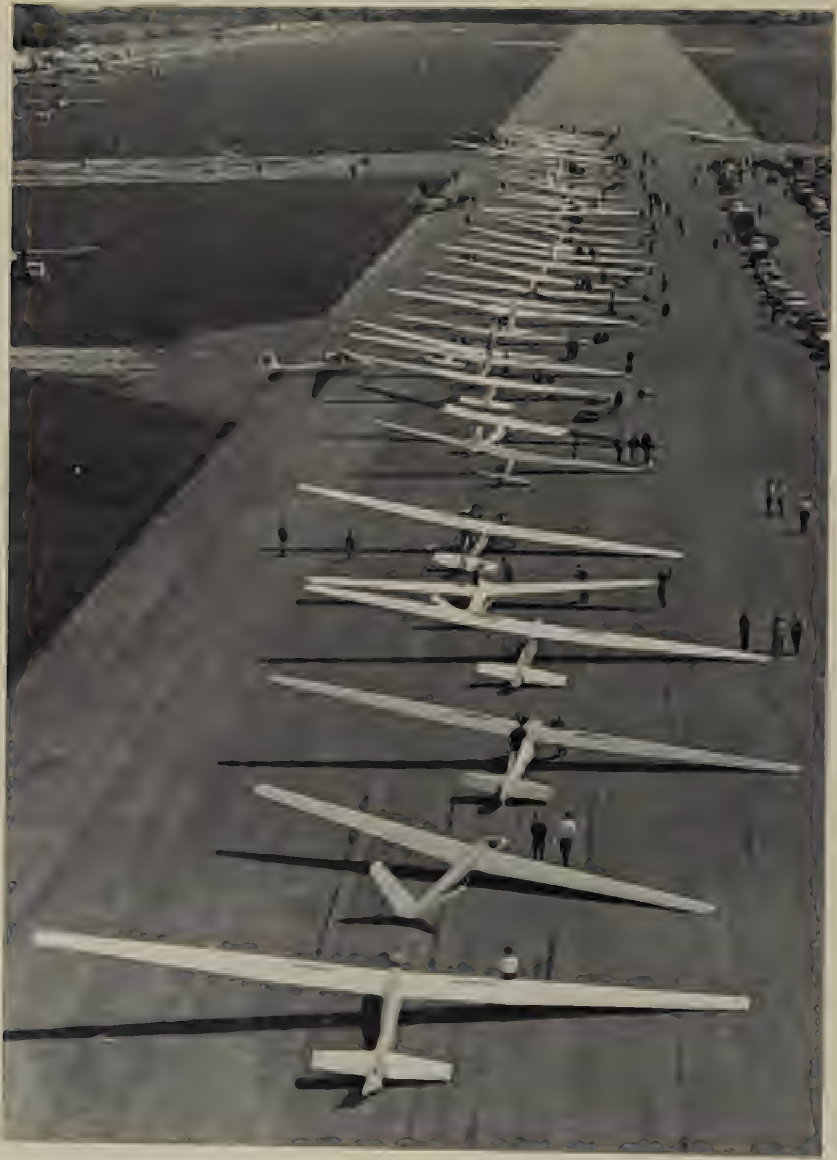
Although the glider pilot is unlikely to go to this trouble to find the compass course for a certain heading, it should now be clear that the readings of the compass can be considerably different from those intended. Whenever the compass is used, every opportunity should be taken to confirm that the glider is actually heading where the pilot wants to go.

The problem becomes even more complex when an attempt is made to use the compass in flight since it suffers several temporary errors during turns and accelerations, and only reads correctly in steady straight flight.

Acceleration and Turning Errors

Owing to the type of suspension of the magnet system in the normal type of aircraft compass, any change of speed or bank causes

PLATE 8



Competitors in the National Gliding Championships at Lasham preparing for take-off

Photograph by Charles E. Brown

temporary error in the reading of the compass so that until steady, straight flight at a constant speed is resumed, the readings of the compass are of little use.

Summarizing these errors, the effects of lowering and raising the nose (gaining or losing speed) are as follows:

Magnetic Heading	*Nose Down Effect*	*Nose Up Effect*
N	Nil	Nil
S	Nil	Nil
E	Indicates an apparent turn to left	Indicates an apparent turn to right
W	Indicates an apparent turn to right	Indicates an apparent turn to left

(These effects are at a maximum on east and west and decrease to a minimum on north and south.)

Turning Errors

If a steady continuous turn is made watching the compass it will be noted that on some headings the movement of the compass is slower and on others much faster than the rate of turn. This makes it difficult to turn on to a definite heading by observing the compass reading, since after the turn is stopped the compass may take time to settle to the actual heading which will not, in all probability, be the one required.

These turning errors are at a maximum on northerly and southerly headings and together with acceleration errors make it extraordinarily difficult to come out of a turn on the required course when instrument flying. If before attempting to straighten up on a definite heading the turn is reduced to a gentler one (rate $\frac{1}{2}$–1 on gliders) the turning error can be more easily appreciated and allowed for, so that approximately the correct heading can be assumed without delay.

The turning errors are such that the pilot should stop the turn at least 30 deg before the desired heading if it is in the northern quadrant or about 30 deg late if it is in the southern quadrant. On easterly or westerly directions there is no turning error, but it takes at least 10 deg to straighten out from even a gentle turn in a glider and this must be allowed for.

These turning and acceleration errors make it vital to settle down in straight flight for some time before attempting to read the compass. A correction can then be made by turning for a judged length of time. A further check of the compass reading can then be made after allowing it to settle down again. In this way, the glider can be turned on to the desired heading in cloud.

In visual conditions, the errors and fluctuations of the compass are of less consequence as the approximate direction can usually be judged by the position of the sun or landmarks on the ground. However, it is still necessary to be flying straight at a constant speed before reading the instrument.

THE COOK COMPASS

The Cook compass has been specially designed for gliding and has few of the errors which makes the normal type of compass so difficult to use.

The magnet system is mounted between two bearings so that it is able to rotate but not tilt. This type of suspension eliminates acceleration errors leaving only the turning errors caused by the angle of "dip".

However when the instrument is mounted so that it can be tilted to be horizontal in relation to the earth's surface in a turn, it is not affected by either acceleration or turning errors. It is then possible to straighten up on to a definite heading after prolonged turning. The pilot must adjust the tilt of the compass during and after each turn, but this is a small inconvenience compared with the advantages gained.

Unfortunately the errors which are caused by not being able to keep the compass exactly horizontal are large and it seems advisable to use a normal type of compass as well to check the glider's direction in steady flight.

This compass has proved to be one of the greatest technical advances in glider instruments for many years.

THE ARTIFICIAL HORIZON

The instruments so far described, the airspeed indicator, altimeter, turn and slip indicator, variometer and compass are sometimes known to powered aircraft pilots as the primary instruments or limited panel. Most powered aircraft are fitted with an artificial horizon and directional indicator which make it much easier to fly accurately by instruments. However, these instruments may have limitations of pitch and roll which render them useless for recovery from steep attitudes such as spins. The primary instruments are much less likely to fail, and except for their inherent errors, can be relied upon when the artificial horizon and directional indicator have toppled through exceeding their limits.

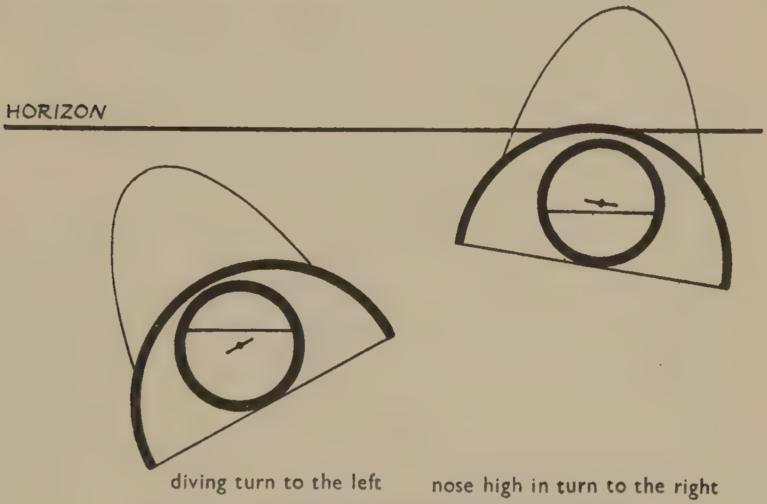


Fig. 67. The indications of the artificial horizon.

The artificial horizon shows both the position of the nose and the angle of bank instantaneously so that safe and accurate instrument flight can be maintained by this one instrument alone, in the same way as in visual conditions the glider can be flown by direct reference to the real horizon. Changes in attitude are indicated, and can be corrected before the glider has had time to change speed. This prevents most of the difficulties arising from gusty conditions which may result in loss of control on primary instruments.

Similarly the directional indicator shows a change in direction immediately, and suffers from none of the errors of the compass since it is not magnetic. It requires resetting fairly frequently to indicate the compass heading because it gradually wanders from the correct readings.

Both of these instruments are expensive and when electrically operated require accumulators and a D.C. to A.C. converter in the glider. In spite of these disadvantages many glider pilots use them and consider the weight well worth while because of the ease and the high standard of instrument flying possible when they are fitted.

Air driven artificial horizon and directional indicators are available but are not recommended because of the drag and risk of icing of the venturi producing the suction to drive them.

Since the artificial horizon can be toppled by allowing the glider to dive or bank very steeply, or may fail through weak batteries, it is essential that glider pilots should be able to fly on the primary instruments alone.

THE BAROGRAPH

The barograph is a recording altimeter which is carried in the glider in order to provide a permanent and definite record of the height of the glider throughout the flight. It is compulsory for all the tests for the International Gliding Awards (Silver, Gold and Diamond "C") and for National and International records.

A barograph is an important part of normal equipment for a modern glider and not just an instrument to be carried on special flights. There is no way of telling when unusual soaring conditions may occur and it is a pity to miss any opportunity for an interesting and perhaps record-breaking flight. For official flights, the instrument must be sealed by an official observer before the flight and remain sealed until it is handed back to an observer after the flight. The trace can then be compared with the calibration chart and the gain of height measured with a pair of dividers. (Club officials and instructors are almost always official observers.)

The instrument consists of an aneroid barometer (or altimeter) recording with a pen on to a revolving drum. A clock mechanism drives the drum at a set rate, usually one revolution every five or six hours, so that the recording pen traces the height from moment to moment on paper round the drum.

Countless experiences of the unreliability of recording in ink has led to the almost universal use of a pen or stylo tracing on smoked paper or aluminium foil. Ordinary smooth paper smoked over a sooty flame can be used and there is no possibility of the pen failing to leave a clear trace. The barograph chart can be made permanent by dipping the paper into a weak solution of shellac and methylated spirits, or cellulose lacquer.

Recording on smoked paper has many advantages over the use of a pen and ink. It cannot freeze at high altitudes, or dry up if the instrument is not used for some time after it has been sealed up. Furthermore, the stylo can give a good trace with only the minimum of pressure (and therefore friction) on the paper. Any barograph can be used with smoked paper without changing the ink pen although a better trace is usually obtained with a specially made stylo.

After smoking the drum, the instrument should be switched on so that the pen is in contact with the paper, and then a base or datum line should be made by turning the drum through a complete revolution. This marks a line from which any measurements of heights can be made. It eliminates errors caused by not having the edge of the paper straight or lined up with the edge of the drum. It is not necessary for the base line to be made on the day of the flight as it is only a datum and need not coincide with the trace made on take off.

The barograph is an expensive instrument but it is important to buy one which will be absolutely reliable and will record any height which you are likely to reach in the future. The clockwork mechanism is vital, as a barograph which stops occasionally is worse than useless. Ideally it should run continuously for at least twelve hours, rotating once every five or six hours, so that it can be started in the morning before the glider leaves the hangar and be left on all day. There is then no possibility of forgetting to switch it on before a flight.

It should record up to about 22,000 feet for normal use and up to 35,000 or 40,000 feet if the glider is likely to be fitted with oxygen equipment. These heights may seem excessive but there have been many cases in the past of the pen going off the top of the drum so that the actual height reached cannot be verified after the flight.

Barographs can be seriously damaged by dropping them or by careless handling.

The barograph should be calibrated by taking it to an aircraft instrument testing department and asking them to put it in an altimeter testing chamber. The ideal calibration chart should show a climb and descent from normal sea level pressure in steps of 1,000 feet over the range of the instrument.

All barographs should be recalibrated every year when possible, and immediately after Gold or Diamond "C" heights or height records as the calibration will be needed for checking. Most pilots like to keep the barograph records of their best flights and mount them in their log books together with a few notes about the flight. Barograph charts can also be analysed to determine the actual achieved rates of climb during the flight and it is interesting to compare these results with those of other pilots who were attempting similar flights on the same day.

CHAPTER 25

INSTRUMENT FLYING

The limitations of the senses of balance—Hearing—Methods of learning to fly by instruments—Preventing and recovering from spiral dives, stalls and spins—Centring in cloud—Interpreting the artificial horizon—Turbulence—Ice formation and Lightning

THE ability to fly a powered aircraft in cloud or at night enables it to be used as a reliable means of transport in all conditions and at all times. The power pilot who cannot fly in all weathers would find himself seriously restricted and might, on occasion, be grounded altogether for long periods of bad weather.

The glider pilot, however, is not under any compulsion to learn to fly on instruments since it is always possible to postpone flying until another day. He will seldom want to fly when the conditions are bad, with low cloud or poor visibility; but the time will come when he climbs in a thermal up to the base of a large cumulus cloud and then regretfully has to leave the strong, smooth lift because he cannot fly by his instruments.

The ability to fly gliders in cloud enables great heights to be obtained which, in turn, enables longer and easier cross-country flights to be made. The cloud base in summer in England is generally between 3,000–5,000 feet, which makes a cross-country flight below cloud a series of short climbs and rather worrying searches for the next area of lift. If a cloud can be successfully exploited, each climb will be much higher, and this immediately increases the probability of finding the next thermal. The rate of climb in the cloud is often up to two or three times the strength of the thermals feeding it from below so that, if the whole flight can be made above cloud base, less time will be spent climbing and more on cruising flight.

It is not difficult to fly by instruments. A pilot must understand the instruments and build up his confidence by constant practice. He must also have an elementary knowledge of the physiological requirements and limitations of his own body.

The main difficulty when learning to fly by instruments is the need to ignore all bodily sensations of balance, and concentrate on the readings of the instruments. This requires practice, to build up confidence to accept the readings of the instruments rather than the sensations of the brain, when the two contradict each other.

Confidence is based on a knowledge of all possible difficulties which may arise, together with the experience of having successfully dealt with such situations before. Over-confidence can be dangerous, particularly in cloud flying, and pilots must never be tempted to conclude that it is easy because their first attempts seem successful. Instrument flying always seems easy until something goes wrong, and a pilot who has never lost control in cloud can have no conception of the real problems.

The instruments would be almost unnecessary if only the senses of balance were reliable. These notes would then only consist of a few comments on the use of the compass. In order to appreciate the need for ignoring the senses, it is worth knowing a little more about the mechanism responsible for our sense of balance.

There are three sources of information which enable the brain to assess balance and position; the eyes, the semi-circular canals of the inner ear, and muscle sense.

The eyes are by far the most reliable sense organ. But when flying in poor visibility or cloud, it is usually impossible to see anything to act as a datum from which to deduce the attitude of the aircraft. It is generally impossible to see beyond the wing tips to see either the angle of bank or the position of the nose in relation to the horizon.

THE SENSE OF BALANCE

The Semi-Circular Canals form a part of the Vestibular apparatus which is a tiny organ of the inner ear. It consists of three semi-circular tubes mounted at right angles to each other and filled with a liquid. Each tube records movements in a different direction, one in the tilting plane, one in the pitching and the third in the horizontal plane. Each tube is connected to a common reservoir which forms a fourth instrument which can detect the direction of the force of gravity or any acceleration acting on the body.

The system has severe limitations, particularly when flying. Normally the information from the semi-circular canals is monitored by the eyesight and misleading sensations are disregarded without conscious effort.

However, false sensations of tipping or turning become so vivid when no correction is available from the eyesight that at first it is impossible to believe that the instruments are reading correctly.

After a few moments of steady turning there is no sensation of turning and a vivid impression of turning in the opposite direction occurs as the turn is stopped.

Small changes are not detected by the semi-circular canals with the result that the glider may get into a very steep turn without the knowledge of the pilot, providing that the entry into the turn is gradual and smooth.

The most disturbing sensations caused in this way occur when recovering from a tight turn or spin. Here the impression of turning or spinning in the opposite direction is most marked as soon as the corrective action begins to take effect, with the result that the pilot may easily stop the correction and continue the spin or turn again. It is unwise to move the position of the head suddenly during instrument flying as this changes the planes of the semi-circular canals and may give violent sensations of turning or pitching which can be most disturbing.

The reservoir to which the canals are connected forms a further instrument consisting of minute hairs with small crystals of lime at the ends submerged in the liquid. If the head is tilted the weight of the crystals bends the hairs giving an indication of tilt. However, when a glider is turning, the loading of the turn will keep the hairs upright provided that the turn is accurate and there will be no sensation of bank. If the turn is not accurate, the load created by the slip or skid will bend the hairs, giving the impression of bank which may be false.

Clearly the vestibular organs of the inner ear, although essential for the normal sense of balance, can give misleading and confusing information which must be disregarded by a pilot flying by instruments.

MUSCLE SENSE

Muscle sense is the impression of attitude deduced by the brain from the sensations of load on the muscles of the body. When these impressions can be used in conjunction with those of vision, they can be most useful. The glider pilot is able to centre accurately in a thermal by the feel of the lift and he can also detect inaccuracies in turns by the sensation of slip and skid. For example, a skidding turn can be detected by the feeling of being thrown towards the outside of the turn.

Since the load on the body varies considerably during normal manoeuvres, the small loads resulting from leaning the body are undetectable and completely swamped by changes in attitude of the aircraft, so that muscle sense is of no assistance in keeping the glider upright in cloud. Furthermore, this sense is unable to distinguish between pitching nose up and flying into rising air, with the result that the pilot will have the impression that the nose of the glider is rising and that a forward movement of the stick will be needed, when, in fact, the glider is in the same attitude but is accelerating upwards. A few seconds later, if sinking air is encountered, the false impression of the nose dropping will be felt and the pilot may over-control and stall the glider. This is nearly always the cause of difficulty when flying in turbulent conditions in cloud and it can only be completely overcome by ignoring the sensations or, with experience, by distinguishing between pitching movements and changes in the rate of climb by the readings of the instruments.

* * * * *

So far, it has been shown how and why the senses of balance cannot be relied upon without the help of a visual horizon or reference point. However, there are other factors which help to confuse the pilot.

Hearing plays a very important part in gliding because the sound of the glider in flight gives the pilot a fair idea of speed and, in particular, changes in speed. If the airspeed indicator becomes inoperative because the pressure head is iced over, the pilot must use his judgement of the noise to keep the glider flying at the right speed. This may seem simple at first, but in turbulent conditions the pilot soon forgets what the ideal speed sounds like, and as the speed increases it may soon sound like a terminal velocity dive and be very frightening.

The sound of hail or thunder and of the cracking ice on the wings as it melts and breaks away, nearly always affects the ability of the pilot to fly on instruments accurately by disturbing his state of mind and morale. It is, therefore, necessary to fly armed with the knowledge of what can happen and what action should be taken, so that nothing is unexpected and, for that reason, disturbing.

Even the most experienced instrument fliers will show a loss of ability towards the end of a long spell of instrument flying. This loss of ability will be accelerated in a less experienced pilot because he is unable to relax and is over-anxious.

Flying fatigue is greatly increased by discomfort, cold and lack of oxygen. It produces an inability to co-ordinate the controls in steady and accurate flight, and a lack of critical sense. By making a conscious effort to relax physically and mentally for a few seconds, it is usually possible to improve the standard of flying.

* * * * *

The art of instrument flying in a glider can either be self-taught by trial and error flying solo, or learnt by receiving dual instruction. In practice, many self-taught pilots never reach a proficient standard because of the rather alarming experiences which occur all too frequently, unless the pilot has a good fundamental knowledge of the problems involved. Very useful experience can be gained by observing the instruments closely when not in cloud so that the readings of the instruments can be interpreted very quickly. It is also possible to wear a visor or fit a small cloth hood over one pilot in a two-seater glider, so that instrument flying can be practised without any possible unconscious cheating.

It must always be remembered that an adequate look-out must be kept when practising instrument flying in clear conditions and that cloud flying may only be carried out away from control zones and civil airways.

There is always the possibility of a failure of one or more instruments in cloud with the result that control may be lost and the glider may be damaged by the excessive speeds and loads encountered during the descent through turbulent areas. For this reason, parachutes should always be worn whenever it is intended to enter cloud. Furthermore, unless the pilot is a skilled instrument flier, the glider should be one fitted with limiting air brakes, so that, in the event of loss of control, he can open the air brakes and prevent high speeds and consequent damage to the glider.

No attempt should be made to fly in cloud unless the glider has adequate serviceable blind flying instruments, i.e. turn and slip, A.S.I., altimeter and compass. It is impossible to fly without at least turn and slip indicator for more than a few moments without getting into difficulties. Generally, if the glider is not fitted with a turn and slip indicator, it is not stressed for cloud flying and should on no account be flown into cloud.

The ideal way of learning to use the instruments in a glider is by flying for short periods in small cumulus clouds. Any difficulties can then be overcome by opening the air brakes and descending into the clear air below. Unfortunately, attempts to get into cloud are often unsuccessful and the surest method of getting instrument flying practice is to have dual instruction using a hood or visor so that only the instruments can be seen. The Link trainer can also provide valuable experience although it can never completely take the place of actual flying.

The first essential is to adopt a philosophical frame of mind and to settle comfortably in the cockpit long before entering cloud. The pilot should always transfer his full attention on to the instruments 200–300 feet below the cloud in order to be absolutely calm and settled down by the time that he enters cloud. If the glider is fitted with an elevator trimmer, it should be adjusted to enable the glider to be flown "hands off" at the correct speed so that it will need the minimum of effort to fly. The position of the turn needle should be noted so that the approximate relationship between the rate of turn indicated and the angle of bank is known.

Normally, the glider will be circling in a thermal when it enters cloud and, in order to continue to use the lift efficiently, a steady turn must be made. In most cases, the pilot is eager to gain as much height as possible and should continue to circle until the lift begins to fail or is lost. Even a short period of straight flight may result in flying out of the cloud or into a down-current and for this reason, as long as the glider is gaining height, the turn should be continued.

The would-be instrument flier should, therefore, concentrate on learning to circle smoothly and accurately by reference to the instruments and should not worry too much about straight flying in the early stages. If the glider has been carefully trimmed in the turn before reaching the cloud, it should not be difficult to maintain the turn. When flying by instruments, attention must be paid to all the significant instruments, i.e. the turn and slip indicator and the air speed indicator, with occasional glances at the variometer and altimeter to check whether the glider is still climbing. Over-concentration on one instrument will result in erratic flying since it is only by interpreting both the turn and slip and A.S.I. that the attitude of the aircraft can be pictured. It is probably easiest to consider the handling of the glider in exactly the same way as in visual flying—the ailerons controlling the angle of bank and consequently the rate of turn, and the elevator controlling the speed. If the rudder is used in co-ordination with the aileron as it is in normal visual flying, no excessive slip or skid should occur. Errors in slip and skid are the least important and only small corrections will be required on the rudder provided that the pilot remains relaxed and allows his normal instinctive rudder movements to occur.

The rate of turn must be kept under complete control, and prevented from increasing by the use of small, but positive movements of the ailerons. Any increase in the rate of turn must be checked immediately by taking off the bank until the correct rate of turn is obtained again.

At first it will be difficult to believe that the turn has steepened because of the lack of any sensation of turning, but action must be taken without delay if a smooth turn is to be resumed without difficulty.

The rate of turn depends on both the angle of bank and the amount of backward movement on the stick. When the nose is raised by moving back on the stick while the glider is being brought out of a diving turn, the turn indicator will register the increase in the rate of turn caused by the pitching movement.

Any increase in speed must be corrected by first, ensuring that the rate of turn is not excessive and then by making a small backward movement on the stick followed by a movement back to its normal position. The rate of turn and airspeed can then be checked again after allowing time for the speed to settle down.

It is important to reduce a large rate of turn before attempting to correct for flying too fast, since if the bank is steep, pulling back on the stick will only tighten the turn and cause the nose to drop instead of rise. In this way, a turn can easily develop into a steep diving turn or spiral dive in which speed is gained very rapidly.

The movement of any control should consist of the following stages (merged smoothly into one action):

a. A movement of the control to change the glider's attitude.
b. A small check movement to prevent the change going too far.
c. Adjustments to maintain the new attitude.

For example, the turn needle is showing too great a rate of turn to the left. Correction: Move the stick to the right to reduce the bank; make a small check movement to the left to prevent over-correction; and then make adjustments to keep the correct position of the turn needle. (The rudder would also be used to assist the aileron, and a correction on the elevator might be needed to re-adjust the airspeed.)

If the turn has become erratic, only calm and patience will enable a smooth turn to be resumed. The use of the air brakes will prevent excessive speeds and help normal flight to be resumed, but once things have got out of hand, the pilot must *expect* to stall and dive several times before sorting it out again. The sensations during this period of oscillation are rather disturbing, but the pilot will be far less worried if he understands the worst that is likely to happen, and knows how to deal with it.

The most usual way in which control is lost is by allowing the glider to become semi-stalled during the turn. Since both the nose and wing will drop, a steep spiral is imminent and will be detected by the high rate of turn and the ever increasing speed together with a rapid loss of height. The correction is to reduce the rate of turn and then ease back to normal flight, guarding against any tendency to over-correct and stall again. (Always open the air brakes if the speed has already increased by more than 20 m.p.h.)

If the speed has already increased by even 20 m.p.h. a very definite pressure will be required to operate the ailerons in order to reduce the bank, and the pilot may make what he considers to be a normal correction without obtaining the desired effect. In recovering from the dive, the tendency is to over-correct and pull the nose up too far resulting in a stall and then another dive.

In exceptional cases the glider may even begin to spin. Present-day gliders, however, will only continue to spin if the pilot keeps the stick back and rudder applied in the direction of the spin. Therefore, unless the stick is held back, the glider will become unstalled during the first half turn of the incipient spin. The speed will then increase very rapidly as the glider spirals down in a steep diving turn. The recovery action is once again: air brakes out, reduce the rate of turn and then ease the glider out of the dive.

Should the speed remain low and almost constant with a maximum rate of turn and a rapid loss of height, the glider is spinning.

If the glider is fitted with a nose pitot and static vents, the needle of the A.S.I. may move back beyond the zero so that it appears to read a high airspeed in the spin. The air brakes should be opened and the normal spin recovery action should be taken. The direction of the spin is indicated by the turn indicator which will be showing a maximum rate of turn in that direction. Apply full opposite rudder to the direction of the spin—pause—and then move steadily forward on the stick until the turn needle flicks across to the other direction. This indicates that the spin has stopped and the rudder should be centralized. The glider is then usually in a steep diving turn, and the rate of turn must therefore be reduced before attempting to raise the nose of the glider to recover to a normal gliding speed. The sensations during a spin or spiral dive recovery are very vivid, and care must be taken to centralize the turn needle before attempting to recover from the dive, or the spiral will only become steeper and faster. The slip indicator usually shows a full deflection in the opposite direction to the turn needle in the spin, but this depends on the spinning characteristics of the glider. Provided that there is at least 2,000 feet of clear air below the cloud, the pilot can feel quite secure in the knowledge that, with the air brakes open, he can, if need be, wait until the glider falls out of the cloud. In many hours of cloud flying in gliders I have never known a glider to spin fully except when deliberately put into a spin for practice. The air brakes should be used as soon as things get out of hand as they make it much easier to regain steady flight and to prevent excessive speed.

In turbulent conditions, it is impossible to maintain exact readings on the instruments but the aim should be to make the needles average the correct position. It is much easier to maintain a steady gentle turn than a steep one, and accurate and completely controlled flight should be the aim. Losing control almost inevitably means losing both height and the best area of the lift.

Centring into the best lift in cloud is not easy. A Cook compass or directional indicator may enable the pilot to orientate himself in the lift and centre accurately. If the turn is partly in lift and partly in sinking air, the turn can be opened out into a gentle turn just after the worst indication of sink. Then as the lift is felt to improve, the turn can be tightened up in order to put the complete circle into the stronger lift. With practice steady steep turns are quite practical and enable the method recommended on page 149 to be used in cloud.

Difficulty in keeping an accurate turn is often caused by the failure to use the elevator correctly when changing the angle of bank. If the angle of bank is allowed to increase (intentionally or otherwise) the backward movement on the stick must be increased to maintain an accurate turn. Otherwise the nose will drop and the speed will increase. Similarly, when reducing the bank, the backward pressure must be reduced or the glider will become stalled.

The sensations of flying into rising or sinking air are at first indistinguishable from those of the nose rising or dropping. The natural reaction to the impression that the nose has risen, is to move forward on the stick with the result that the glider is actually put into a dive. This usually results in the glider flying out of the area of lift into a down-draught. Then the pilot raises the nose acting under the impression that it has dropped. These effects, combined with the increase in airspeed occurring as the glider enters rising air, and the decrease as it enters sinking air, result in over-controlling with the risk of diving or stalling. The beginner should ignore everything except the actual readings of the instruments. These, subject to their individual inherent errors, are the only reliable guide to the pilot flying in cloud.

A most disconcerting sensation of flying upside down occurs whenever the nose of the glider is lowered too rapidly—generally if the pilot overdoes the stall recovery action. On instruments, it is usually easier to allow the nose to drop naturally when a stall occurs, checking any change in rate of turn with the rudder and keeping the stick more or less in the normal position so that no extreme attitude is reached. It is almost impossible to get into an inverted position unintentionally and, in any case the glider would fall into a normal dive after a few seconds so that no special recovery need be considered for such a situation.

The delay in changing speed after a change of attitude becomes very large when the glider gets into steep climbing or diving attitudes. A useful guide to recovery to level flight is to apply the correction until the change in speed is arrested and then to make a check movement to hold that position while the speed settles down. This will enable extreme attitudes to be damped out quickly without over-controlling and a series of violent stalls and dives will be avoided.

For example, if the speed is increasing rapidly, a backward movement is made until the increase in speed is checked and is about to decrease. A small forward movement on the stick then prevents the nose rising farther and, after a few seconds, the speed will fall to approximately cruising speed so that final adjustments can easily be made. This idea can be tested in clear conditions and it will be found that the nose of the glider is at approximately the correct position as the speed is momentarily constant.

As the turn is stopped by levelling the wings until the turn needle is central, care must be taken to maintain the correct speed by easing forward on the stick. There is a tendency to stall the glider coming out of a turn because during the turn a constant backward pressure or trim is used to prevent the nose from dropping and this has to be taken off in contradiction to the sensations felt at the time, which produces a feeling of diving when in fact the nose may be too high.

This will be avoided by ignoring the sensations and trusting implicitly in the readings of all the instruments. A few seconds over-concentration on the turn indicator will almost certainly result in a very low air speed and a possible stall before any correction can be made.

When the glider is circling, the readings on the compass are confusing, and in some cases, the compass may spin freely so that no indication of direction can be obtained. In this case a gradual reduction in angle of bank and rate of turn may allow it to settle down so that some idea of the heading can be deduced in spite of the turning and acceleration errors at the time.

The pilot should try to picture the attitude of the glider from the indications of the instruments, and anticipate the possible movements of it so that no change comes as a surprise. This is considerably simplified by the use of the artificial horizon which has no time lag and suffers only minor errors. However, even when an artificial horizon is fitted, it is essential that the pilot is able to manage on the turn and slip indicator and air speed indicator since unless the batteries are fully charged and in good condition there is always a chance of it failing.

The artificial horizon is best interpreted by imagining the view from the tailplane looking forward. The wings and body of the glider are represented by the miniature aeroplane and the horizon by the horizon bar of the instrument. In the normal gliding attitude, the little aeroplane will take up a position on or just below the horizon bar with the wings level. In a nose-up position, the aeroplane will appear higher in relation to the horizon bar in exactly the same way as the pilot would see the real horizon if he was sitting on the tail. The miniature aeroplane in the instrument is fixed and the horizon tilts and moves up and down to register the changes in attitude of the aircraft. (Fig. 67 on page 203.)

After a little practice turning in clear air and referring to this instrument, the use of the artificial horizon becomes more or less instinctive and a very high standard of accuracy can be maintained. However, it is vital to observe all the instruments and not just concentrate on one, or a difficult situation will arise if the artificial horizon fails.

Perhaps the most essential thing with an artificial horizon is to keep the accumulators fully charged and in good condition. An unreliable horizon is much worse than no horizon at all. Avoid testing the instrument unless it is absolutely essential because the starting load on the accumulators is very large. It is best to allow the instrument to run for several minutes, before uncaging it while the wings are held level for a moment. If it does topple in flight it will re-erect itself gradually. It should always be caged for take off or landing and for aerobatics.

TURBULENCE AND ICE FORMATION

Turbulence in clouds is rather unpredictable and varies considerably from cloud to cloud. If the cloud is developing from a large cumulus into a cumulo nimbus or storm cloud, the conditions may, at times, be very violent with rates of climb of 1,000–2,000 feet per minute and similar down-draughts in places. These powerful air currents can be smooth and cover a large area, making a climb on instruments a comparatively simple matter. However, it is usual to find very turbulent conditions near the top of the cloud—generally above freezing level, making it difficult to continue climbing and sometimes even desirable to steer out of the cloud. If the pilot concentrates on maintaining just a gentle turn, most of the bumps can be ignored; indeed any attempt to correct for them will only result in over-concentration and subsequent over-controlling. Most of the bumps will be vertical currents lifting the whole glider up or down, or banking it over, and few will cause much nose up or down change in attitude in spite of the misleading sensations to the contrary which are felt by the pilot.

The decision whether to enter a particular cloud should be taken while there is still time to fly away from it without being sucked into the bottom. If the day is one with only small cumulus, there is little risk for the most inexperienced instrument pilot, providing that the aircraft has adequate air brakes. But if the cloud is massive and tending to develop into thunder-heads, it is not the right day for starting to learn to fly by instruments.

Thunderstorms were once considered to be things to be avoided at any price and this still is good advice to all but the most competent instrument fliers. There is always some risk of structural failure flying in them, although if the glider is kept down to normal flying speeds, this is almost negligible. However, when the turbulence is violent, it is easy to lose control of the situation and overstress the glider in regaining control.

It is vital to keep the speed from becoming too high since if the glider flies from a violent up-draught into a down-draught or vice versa at high speed, the loads on the wings may exceed the design strength with consequent risk of failure.

Damage may also be caused by large hailstones penetrating the leading edges, etc.

Storm flying should be quite practical for ex-power pilots with instrument flying experience, but should be approached with caution by others until some experience has been gained in cloud flying in turbulent conditions in smaller clouds.

As the glider reaches the freezing level, ice will begin to form on the nose, leading edges and the front of the canopy or windscreen. This will increase steadily until either the glider is too high for ice to form, or the weight and drag of the ice forces it down. Unless some form of nose vent or pitot heating is fitted, the ice will gradually obstruct the pressure head for the airspeed indicator until it ceases to read changes in speed. It is then necessary to judge the airspeed by the sound of the airflow. This is not difficult and should be practised by holding one hand over the airspeed indicator and getting used to the idea as soon as icing begins, so that the pilot can await the failure of the instrument with reasonable confidence. It is unlikely that the flying controls will be affected by ice formation since most of the ice forms on the leading edge. Exercising the controls from time to time will free them or give warning of serious icing. The air brakes are probably best left alone unless required in emergency to check the speed as they will easily jam open if only a slight film of ice forms on the front. This will prevent them being closed again until the ice has melted off lower down, and in an extreme case it might mean a forced landing with the brakes jammed out.

Airframe icing is seldom very severe on gliders because of the very low flying speed and the short time spent in the icing region of the cloud during a climb. It does spoil the shape of the leading edge of the wing and reduces the efficiency of the glider considerably, as well as increasing the weight and, therefore, the stalling speed.

Icing generally occurs at temperatures between 32°F and 15°F which represents a layer of cloud about 5,000 feet in depth. Above this level the water droplets have normally frozen into ice crystals or snow. It is interesting to note that water droplets can exist unfrozen as water at temperatures far below freezing point provided that they are comparatively undisturbed. These super-cooled water droplets, as they are called, freeze immediately on impact with the surfaces of the aircraft, forming ice. The glider pilot should avoid staying in the icing region unless the glider is climbing rapidly, and should straighten up and look for stronger lift, or leave the cloud if the lift is poor, to avoid collecting more ice than is absolutely necessary. A thin layer of ice melts very quickly once the glider is below the freezing level. When the pieces of ice are swept away by the airstream, the noise of the ice breaking and striking other parts of the glider can be quite alarming, and the pilot should be prepared for this or he may think that the aircraft is breaking up.

Heavy rain is also rather alarming and may render the A.S.I. temporarily unserviceable. Protection against rain and hailstones is vital in an open cockpit glider, unless the windscreen is very close to the pilot's face. A helmet and goggles together with something to protect the nose and face (an old R.A.F. oxygen mask or scarf is very good) are essential where the pilot is exposed, as heavy rain or hail is extremely painful and, without protection, usually makes it impossible to carry on.

Sometimes the hail or melting ice does considerable damage to the glider which cannot be seen from the cockpit and it is therefore unwise to carry out any aerobatics or fly at very high speeds after flying in severe conditions.

At very low temperatures the controls may become excessively stiff because of the contraction of the control rods and cables. Also the wood, perspex, and other materials in the glider may be temporarily below their normal strength because of shrinkage or frozen moisture.

A further considerable difficulty is the moisture from the pilot's breath condensing and freezing on the inside of the canopy, so that it is difficult to see out except through the clear vision windows. This can be prevented by wiping it with a rag soaked with an anti-icing fluid such as glycol which can be carried in a tin.

LIGHTNING

The greatest danger from lightning in a glider is probably the risk that the pilot may be panicked into losing control.

However, experience over the last few years has shown that there is a considerable risk of gliders being struck and that severe damage is often caused. Even on occasions when no external damage has been found and the pilot was unaware of a strike, control cables have been found burnt through to the last few strands. For this reason it has become the recommended practice to remove and inspect all control cables after any flight in an active thunderstorm.

When the glider does become heavily charged with static electricity the pilot may feel "pin prick" shocks from the control column or other metal parts of the aircraft. This is quite common when the glider is being launched in very dry or thundery weather even when there are no actual storms near by. In this case sparks several inches long can be drawn from the cable release knob by putting a hand anywhere near it.

Severe shocks may be felt if the glider is actually struck and these are particularly unnerving because there is no way of knowing when they will occur or when they are likely to stop. The strikes cause burn marks and slight damage to the glider.

I was once struck by lightning in flight in a glider and it was very alarming. It is a sobering thought that the strikes were probably only minor "feeler" sparks or this would never have been written.

It is worth mentioning that in a moment of mental stress the pilot may start to breathe heavily, which can result in a condition known as hyperventilation of the lungs. This upsets the critical balance of carbon dioxide in the lungs, which stimulates the respiratory system and may cause unconsciousness in a few minutes. Care should be taken to avoid deep breathing as this will increase the pilot's susceptibility to lack of oxygen. Even at sea level it is fairly simple to produce fainting by over-breathing, so that at 10,000–15,000 feet the effects of lack of oxygen may be very pronounced if the pilot gets a nasty fright and begins to breath heavily. Rapid shallow breathing does not have this effect and is quite safe at any time.

Cloud flying has opened a whole new range of experiences for the glider pilot. Some of them are pleasant and peaceful, others overawing and spectacular. Few pilots will deny that there is a tremendous thrill to be gained from surging upwards at thousands of feet per minute to come out of cloud on top of the world with a view of, for example, the whole of the south coast from Portland Bill to the Thames Estuary.

* * * * *

To be really successful at cloud flying, the pilot must be able to interpret the instruments and fly the glider accurately while censoring any sensations of pitching and turning which might cause him to doubt or disbelieve the instruments. At the same time, he must maintain a mental picture of the strength and position of the best lift by the combination of his sense of feel and the readings of the variometer.

As Phillip Wills said, "instrument flying is a state of mind". Try it first before you decide whether you consider it is a sane one or not!

CHAPTER 26

FLYING HIGH

Anoxia—Effects of lack of oxygen on the pilot—Other effects of flying high—Oxygen equipment and precautions to take when using it

ONCE the glider pilot has mastered the art of instrument flying, the enormous energy available in storm clouds can be tapped, and heights of 30,000–40,000 feet become possible. Flights in clouds of this kind, and in large scale standing wave conditions, are now becoming sufficiently common for many of the dangers to be overlooked in a rush of enthusiasm to take advantage of the conditions when they exist.

The ambitious glider pilot must face many of the same problems of survival at high altitudes as the jet pilot, and must understand the need and use of oxygen equipment if such flights are to be made safely. Without this equipment, high flying is dangerous since the glider may be carried up several thousands of feet while the pilot is attempting to fly out of the lift. This might well result in the pilot losing consciousness at the controls.

The seriousness of the effects of lack of oxygen cannot be overstressed. The tolerance of each individual varies considerably and is affected by day to day health, so that it is difficult to give a safe height not to exceed without oxygen. It is certainly dangerous to assume that because glider pilots have reached over 20,000 feet without oxygen and lived to tell the tale that others can safely do so. Such heights without oxygen involve a considerable risk even when the pilot is well aware of his personal capacity from experience at those heights or by tests in a decompression chamber.

The exhilaration of an exciting height climb, together with the effects of slight anoxia may lead to over-confidence and cause the pilot to make serious blunders in airmanship and judgement. Special care should be taken when making field landings after any climb which may have been high enough to cause even slight anoxia.

It is the nature of the symptoms of lack of oxygen which make it particularly dangerous. The brain is affected in much the same way as with alcoholic intoxication. At first, there is usually a feeling of well-being and over-confidence, and inaccuracies in flying go unchecked. This is followed by a progressive lack of concentration so that, even if the aircraft is not under complete control, the victim is neither really interested nor able to do anything about the situation. Finally, loss of consciousness and even death occurs unless the supply of oxygen is restored.

Oxygen is absolutely essential for life and a continuous and adequate supply must be available all the time, since, for all practical purposes, the body is unable to store it up. The oxygen is absorbed into the blood which is pumped to the brain and all the parts of the body. Moreover, a shortage of oxygen has an almost immediate effect on the brain causing a loss of mental acuity, although this is normally undetected by the person concerned.

The atmosphere consists of a mixture of about one part of oxygen and four parts of nitrogen and very small amounts of other gases. The pressure decreases with height but the proportions of oxygen and nitrogen remain the same, so that oxygen is still available in the air at height, but only in greatly reduced quantities. When the air is breathed, the atmospheric pressure forces the oxygen into the blood. However, if the pressure of the air is reduced, less oxygen can be absorbed by the blood, and oxygen starvation occurs. This can be averted by providing additional oxygen to take the place of some or all of the nitrogen in the air so that the required pressure of oxygen is maintained all the time. Above about 38,000 feet the pressure is so low that, even breathing pure oxygen, there is insufficient pressure to force an adequate supply into the blood and the only satisfactory solution to the problem is to provide the pilot with a pressure suit or cabin. In effect the situation in this case is similar to that above 15,000 feet without any oxygen equipment.

The human body is most suited to the atmospheric conditions found at sea level. There, the air pressure is about 14.7 pounds per square inch providing the equivalent pressure of 3 pounds per square inch of oxygen. Although we are able to acclimate ourselves to heights of 10,000 or even 20,000 feet over a period of days or weeks, a slight but definite loss of efficiency occurs when flying as low as 10,000 feet if that height is maintained for more than an hour.

At about 15,000 feet, a marked deterioration begins in the average individual which would be noticed by an observer although quite unobserved by the individual himself. It is unwise to attempt flights above this height without oxygen equipment. Even the slightest anoxia is enough to prevent most glider pilots from flying accurately on the turn and slip indicator, particularly in turbulent conditions.

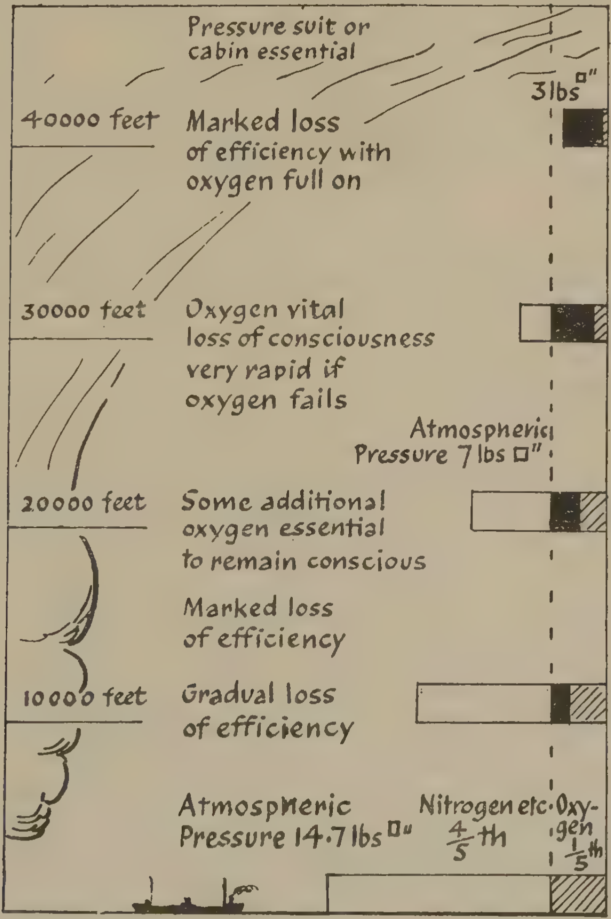

Pressure suit or cabin essential
3 lbs □"
40000 feet
Marked loss of efficiency with oxygen full on
30000 feet
Oxygen vital loss of consciousness very rapid if oxygen fails
Atmospheric Pressure 7 lbs □"
20000 feet
Some additional oxygen essential to remain conscious
Marked loss of efficiency
10000 feet
Gradual loss of efficiency
Atmospheric Pressure 14·7 lbs □"
Nitrogen etc. 4/5 th
Oxygen 1/5 th

Fig. 68. The need for oxygen at high altitudes. Cross hatched areas show the pressure of oxygen in normal air. Shaded areas show the additional oxygen needed to maintain sea level conditions.

Note. At 40,000 feet even using 100 per cent oxygen the pressure of oxygen is less than at sea level and the pilot will suffer.

Decompression chamber tests show that most pilots pass out after a short time between 15,000–20,000 feet.

In an enclosed cockpit there is seldom much ventilation so that, after a time, the oxygen available in the air becomes depleted. In this way the effects of lack of oxygen may well occur below the normal height, and symptoms should be watched for when flying above 10,000 feet. Most gliders have one or more clear vision panels in the canopy which should be opened periodically at height to introduce fresh air into the cockpit.

Fatigue and exposure increase the effect of oxygen starvation and the pilot must keep warm and comfortable if he is to soar efficiently.

The effects of lack of oxygen at height are summarized in Fig. 68 but it cannot be too strongly emphasized that every individual varies in tolerance.

If the pilot keeps a constant check on his reactions a descent can be made immediately any symptoms of trouble are noticed. These may include light-headedness, over-confidence and any kind of visual aberation, such as difficulty in reading the instruments or even the figures appearing upside down.

Airsickness, or a fit of coughing, can be dangerous at great heights since they make it difficult to use an oxygen mask. In a tandem two-seater, a careful check should be kept on the second pilot who is far more prone to sickness than the pilot handling the controls. If he does have to remove his oxygen mask or suffers from lack of oxygen through some other cause, he may be unable to attract attention to the fact, even if he realizes it in time.

The reduction in atmospheric pressure at great heights causes other uncomfortable effects on the body which may, in extreme cases, necessitate the curtailment of a flight. Starchy and gassy foods should be avoided as they can give rise to great discomfort at height when the gases formed in the stomach expand under the reduced pressure. It is also possible to suffer from "bends", a very painful kind of cramp caused by bubbles of nitrogen forming in the blood stream and obstructing the flow of blood. In some cases this can result in sudden unconsciousness without warning. The nitrogen bubbles redissolve in the blood when height is lost putting right the cause of the trouble.

It is unwise to attempt a height climb with a cold when the sinuses may be blocked. The change of pressure gives rise to acute pains across the eyes, and the ear drums may be damaged if the descent is very rapid and the pressure in the inner ear cannot be relieved. This can usually be done by swallowing or chewing, or by pinching the nose and blowing. In any case flying with a cold should be avoided as it can give rise to inner ear infections and deafness.

Height climbs to over 10,000 feet in open gliders are mainly a matter of physical endurance, as the temperature is usually well below freezing, and ice and hoar frost form on the pilot's head and shoulders. Exposure reduces the pilot's efficiency to such a degree that keeping warm is probably the most important single factor governing how high it is possible to go without special equipment.

There can be no doubt that safe and successful high flying can only be the result of careful preparation and the use of efficient oxygen equipment.

The normal British oxygen systems consist of a steel cylinder of compressed oxygen at about 1,800 pounds per square inch pressure supplying a steady flow of oxygen into a reservoir (known as the economiser) from which it is drawn breath by breath.

It is usual to have main ON-OFF supply valve, a contents gauge showing the amount of oxygen left, and a flow indicator and adjustment valve so that the quantity of oxygen delivered can be accurately adjusted. Oxygen is supplied at low pressure to the economiser from which it can be breathed through a simple type of face mask. In most installations, the economiser takes the form of a small plastic bag attached to the mask.

A supply gauge may be calibrated for height so that the supply can be adjusted according to the height at the time, or there may be only a flow indicator and a regulator which may be switched to NORMAL — HIGH — EMERGENCY. (NORMAL: 10,000–25,000 feet. HIGH: 25,000–40,000 feet. EMERGENCY: 40,000 feet or at any time lack of oxygen is suspected and immediately before baling out at high altitudes.)

The fitting and condition of the oxygen mask is most important as the oxygen will be seriously diluted by air leaking into a badly fitting mask. Above 25,000 feet, a leakage of this sort might be disastrous as pure oxygen is needed to maintain consciousness.

It is also vital that the main ON-OFF valve is turned on as far as it will go and not just until the contents gauge indicates the contents. Unless this is done, the flow of oxygen will be restricted and may be inadequate at height in spite of the indicator reading correctly.

Moisture from the breath may freeze in the mask and block the inlet valve. In most cases this can be easily broken up by flexing the mask or the inlet tube, but a constant check for this and all other possible causes of failure must be *kept all the time* above 20,000 feet.

POINTS TO WATCH WHEN USING OXYGEN EQUIPMENT

1. No oil or grease may be used on or near oxygen equipment as this may cause an explosion on contact with the oxygen.
2. Check the complete system, including mask, for leakage regularly.
3. Before take off, check the contents indicator and turn on the main valve as far as it will go.
4. Ensure that oxygen flows freely into the mask.

Remember that oxygen is no use if the pilot is insufficiently skilled to make use of the conditions, or if the instruments are unserviceable. Only systematic care will ensure that all the vital things are serviceable on the day they are needed.

CHAPTER 27

FINDING YOUR WAY IN THE AIR

The need for good planning—Air maps for gliding—Selecting the goal—Preparation of the map and log—The flight: Map reading, good and bad pin-points, what to do when uncertain of your position

GOOD flight planning is one of the secrets of successful cross-country flying. The glider pilot is generally fully occupied with the task of soaring efficiently and looking for promising conditions ahead and does not want to have to spend much time navigating.

On most glider flights the navigation consists of map reading from feature to feature along the required track. If part of the flight is in cloud it will be essential to know the compass course to steer between thermals. This should be estimated before the flight when there is time to check it.

A few minutes spent studying the map before the flight will reveal the most obvious features which will enable the glider's position to be checked quickly and without doubt.

Map reading is largely a matter of experience, logical thinking, and the refusal to become flustered. Great Britain is a difficult country for map reading because there are so many apparently similar features to confuse a beginner. It is always much more difficult to find out where you are than to confirm your position when it is known.

The pilot must be able to identify his position quickly by reference to a map and this necessitates a good knowledge of the symbols used on them, and the ability to recognize the features on the ground. The glider pilot will find map reading easier if he knows the country below him either from previous flying experience or even by having travelled through it by road.

Seen from the air, only the most prominent features are of value and, in Great Britain, such features are often so close together that they can easily be confused with each other if taken individually. A reliable pin-point is usually one in which two or three prominent features correspond exactly with those shown on the map. Air maps are specially produced to mark those features which can be easily identified from the air.

The most useful maps for normal cross-country flights are the quarter and the half-million series (1 : 500,000 is approximately eight miles to the inch), both of which are available at most gliding or flying clubs. For glider cross-countries, if anything the quarter-million shows too much detail and the half-million scale rather too little. They both are overprinted with the airways and other controlled air space.

SELECTING THE GOAL

The aim of most first cross-country flights is to fulfil the requirements for the Silver "C" distance leg. The flight must be at least 50 kms. (32 miles) with a maximum difference of height between the release and the landing place of not more than 1 per cent of the distance covered. Fig. 69 shows the minimum distances required in different circumstances. It is usually easiest to fly down wind for such flights unless the wind is very light or the terrain difficult or impossible for landing.

A definite goal should be chosen for every cross-country flight. If it is easily reached, the flight can always be continued towards a more distant one. A long flight to a declared goal is obviously more creditable than a casual wander down wind. This is reflected in the requirements for Gold "C" and Diamond awards. (See p. 251.)

The more experienced pilot should plan flights to suit various wind and weather conditions so that he has a number of possible flights in mind for each wind direction. After considering the weather forecast he can then select a suitable task, and test his judgement of the conditions and his skill as a soaring pilot.

Triangular courses and out and return flights are much more interesting than a straight dash downwind, and reduce the distance of any possible retrieve.

The selection of a goal presents an interesting problem. The pilot must first consider the weather. How high is the cloud base and how high will it become during the day? Is it likely to over-develop or is there any high or medium level cloud to obscure the sun and limit the distance travelled. Will the thermals be strong enough to ensure a good average speed? Are there likely to be cloud streets which could help progress directly into or down wind?

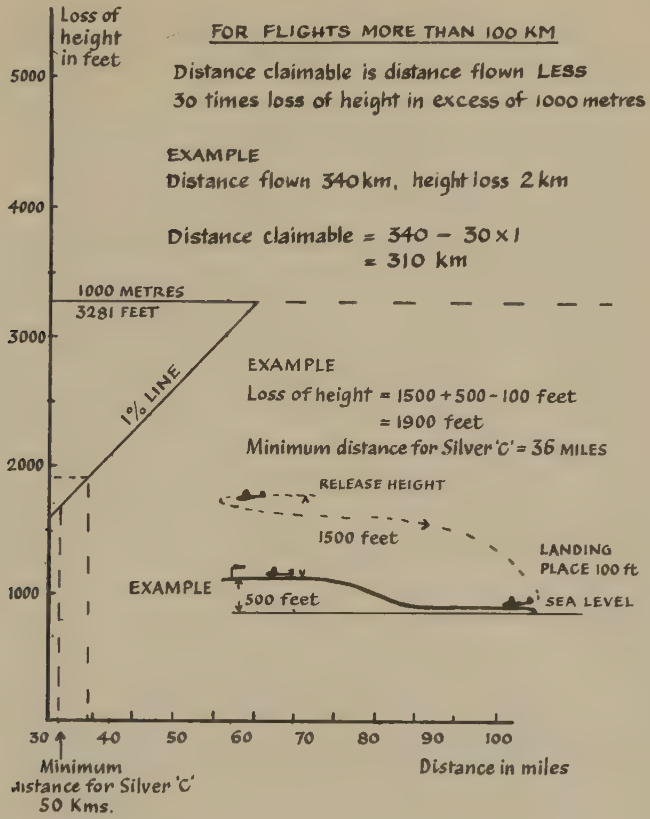


Fig. 69. Chart to show the maximum permitted loss of height for recognized flights.

If the wind is less than 15 m.p.h. at cruising height it should be possible to fly in any direction in a modern glider. But before declaring a goal the pilot should always ask himself what average ground speed he can hope to make and how many hours of soaring he is likely to have. This will prevent him declaring an impossible goal.

Down wind flights of over 187 miles for Gold "C" and Diamond distance awards are only possible when the weather conditions are excellent over a large part of the country. This occurs on relatively few days in each year and it is difficult to forecast them with certainty.

However, such distances can be flown on more frequent occasions if they are made in two or three legs. Careful planning may enable good soaring conditions in the vicinity of hills and mountains or the sea breeze front, to be used to supplement the normal thermal soaring.

For example, if the wind strength is sufficient to ensure good wave or hill lift, it may be well worth while planning a flight across-wind in order to use this lift from a long ridge of hills at the beginning or end of the day when the thermal activity is likely to be poor.

Late in the day it may be possible to use the lift at the edge of the sea breeze to cruise at high speed parallel with the coast line. This sea breeze "front" will vary in strength with the degree of heating of the land, and the direction and strength of the wind in relation to the coast line. The lift will be strongest when the wind blows directly off shore, and will be poor and farther inland where the coast line bends parallel with the wind.

Areas which are poor thermal producers must be avoided, and many of these are obvious from an examination of the map. Low lying country such as estuaries are normally poor for soaring, but if the conditions are very unstable, the additional moisture from the damp ground may help to produce large cumulus clouds or even thunderstorms.

Whenever possible, declare a recognized airfield as the goal as there is then no risk of damage to the glider or of causing annoyance to farmers. A landing within the perimeter track of an airfield or within 1,000 metres of the declared place constitutes a goal flight.

For an out and return flight or a dog leg or triangular course, the turning points must be photographed or the glider must be identified by a reliable observer.

A signed declaration of the goal with the date and time must be made before take off if the flight is to be officially recognized.

PREPARATION

First the intended track should be marked clearly on the maps in pencil, and the direction of the track measured against the nearest north-south grid line or meridian to the mid point of the track. If the track passes near a control zone or airway, these should be marked clearly as a reminder to avoid cloud flying in that vicinity. The maps should then be folded to enable the whole track to be read without the need for refolding them in flight more than is absolutely necessary. (There is nothing more awkward than trying to refold a map with one hand, or while attempting to fly the glider with the stick between your knees.)

The next thing is to mark off the track in intervals of ten miles so that the approximate ground speed can be quickly estimated at the start of the flight for use later on in event of flying in cloud or poor visibility. Where the flight is a race or a record attempt, it may be considered better to divide the track into intervals representing ten or fifteen minutes' flying at the estimated average cruising speed. This enables the pilot to judge how things are going without mental calculations.

In any case, if the flight is intended to be a long one, it is a sound scheme to make half-way and three-quarter way marks with the last time of arrival which will still allow the goal to be reached. If the conditions are poor, or time is wasted during the first two or three hours, it may be quite impossible to make up the time later in the flight and it may be better to turn back and reduce the retrieving distance.

Where the track lies almost down wind there will be no drift off course, but care should be taken to allow for the variation to obtain the correct magnetic heading of the track. (See p. 199.)

If the track is more than 20 deg across wind, an allowance for drift must be made during the glide between thermals. This has to take into account the effect of the wind during the climb and the glide, and is, therefore, quite a large angle for even moderate winds. An approximate course can be estimated by assuming a certain cruising speed and this will avoid serious errors if the glider is flown in cloud early on the flight.

Generally, it is better to keep slightly up wind of the desired track while the thermals are strong. It is then possible to cruise down wind when conditions deteriorate.

A well selected course allowing for drift may save many miles of fumbling, and this is one way in which an expert will score against an inexperienced pilot in competition flying.

A small knee pad strapped lightly to one leg and fitted with an attachment for a wrist watch or stop watch is most useful. A pencil should be attached to the pad so that it cannot be lost in the bottom of the cockpit. The information so far obtained can now be made up in a convenient form for use during the flight. The forecast winds, magnetic tracks, distances and times can be written at the top of the log for easy reference, and the rest of the sheet ruled off into columns.

THE FLIGHT

The time and height of the launch should be noted on the log and, if necessary, the launch point must be emphasized by descending to register a low point on the barograph. (See Chapter 17 on aero-towing.)

If the first town or pin-point near the track has been spotted during the climb, it is a simple matter to stop circling as the lift peters out and turn towards this point straight away so that height is not wasted trying to get on the right course by direct reference to the compass.

The map should be orientated so that features shown on it can be easily compared with the actual features on the ground. It is easiest to note distinctive features on the map and then look for them on the ground; this is the correct method to use provided that the position of the glider is known to within a few miles. Combinations of railways, rivers, main roads and towns are generally satisfactory for pin-pointing, particularly if the feature is across the track and is unlikely to be missed. For example, if the map shows a main railway line running across the track with a distinctive shaped side-line joining it by a small town and a canal running alongside, the pilot need only look out for the railway and canal. When these are spotted, a further glance at the map will show the relative positions of the features and so determine the exact position of the glider. Care must be taken not to jump to a conclusion based on the appearance of one feature. It is comparatively simple to get miles off track by a combination of course errors and a change in wind, so that it is quite likely that there may be two or three features inside the possible area which taken singly would satisfy that shown on the map.

It is vital, therefore, to check any pin-point to make sure that all the features confirm the position. No map is completely up to date, and it is always possible to miss a feature which is marked clearly on the map.

Most beginners attempt to find every detail instead of relying on main features spaced at reasonable intervals. This leads to a feeling of uncertainty if something is not marked on the map or if some feature slips by unnoticed on the ground in the shadow of the clouds. There is also a tendency to forget the scale of the map and the relative distances between features on the ground so that they may be wrongly identified. This is often the case using the quarter-inch to the mile map when small villages and roads are easily confused and seldom constitute a sound pin-point by themselves.

Airfields are not good landmarks unless they can be definitely identified by the letters near the signals area or other confirming features. A very large number of disused airfields will not be found marked and, similarly, airfields may have been constructed since the map was printed. However, they are good thermal producing areas since they are well drained and may have large areas of concrete runways and perimeters which warm up quickly in the sun. A slight diversion to identify the airfield is, therefore, seldom entirely wasted.

Roads do not in themselves constitute good pin-points since only the major roads are shown on the map, and it is difficult to distinguish between main roads and other wide roads from several thousand feet high. Also, many of the major roads are, in fact, mere lanes.

Rivers and canals are useful features because in most parts of the country they are sufficiently rare to be unmistakable. However, from 4,000 feet or so it is sometimes difficult to distinguish between roads, railways and canals because of the shadows thrown across them by trees. Small rivers and lakes may become dried up in summer or may flood over the surrounding countryside, making them difficult to identify. Often the distinctive shape of the river may provide an accurate pin-point and road or rail bridges over them may provide an easy way of identifying the exact position.

Small towns often have a collection of minor features which provide definite identification but larger towns and industrial areas may be very difficult to identify because of the mass of conflicting evidence which can be seen. The town may have increased in size and have railway junctions running to the factories which are not marked on the map.

Large areas of woodland may be identified by their shape on the map, but may have changed since the survey.

Physical features such as hills and mountains form good aids to pin-pointing but are not easily seen from high up.

WHAT TO DO WHEN UNCERTAIN OF POSITION

Although it is comparatively easy to map-read from place to place along a track, it is much more difficult to find where you are once you have become lost. The chances of putting things right are greatly reduced when the pilot is perturbed by the situation and starts making wild guesses, at the same time flying inefficiently and losing height. In a glider, provided that there is ground and not sea below, there is no additional risk in carrying on. It is best to accept the fact that you are temporarily lost and settle down to find where you have gone wrong.

The flight should be continued using the course as planned and no change should be made, except to keep in good soaring conditions, until a definite pin-point has been found.

Unless the ground is known from previous experience, it is almost always a waste of time trying to find out your position until a straight course is resumed.

The first thing is to check back on the map to the last reliable pin-point. This may mean considering whether the last pin-points were correct or might have been wrong. A wrong pin-point might be based on one or more rather unreliable feature. (Remember, roads, villages, airfields, woods and, in some circumstances, rivers may be suspect since they may be incorrectly marked or not marked at all.) If a note of the time and place was made in the log, it is easy to find out how long it is since leaving that position and the approximate distance flown can then be estimated. In general, it is unlikely that the error in position will ever exceed one-third of the distance travelled from the last pin-point, except in very poor soaring conditions when virtually no progress may be made. If a rough circle is drawn round the estimated position with a radius of about one-third of the distance from the last definite pin-point, the search can then be concentrated on that part of the map. A good look-out must now be kept for features on the ground which may be identified on the map, Where the feature is a railway or similar straight line object, the direction should be carefully noted so that it can be distinguished on the map from other similar features running in different directions.

The position of several main features relative to each other along the direction of flight will normally narrow down the search to one or two possible positions on the map. It is then easy to confirm the position by the next feature.

Unless the glider has been in cloud for some time, it is unlikely that it is far off track and, in practice, the most common reason for being uncertain of position is impatience in waiting for the expected features to appear on the ground. This gives rise to the assumption that they must have been overlooked and soon the pilot may be attempting to map-read many miles ahead of his actual position, naturally without success.

The identification letters on Service aerodromes and the aerodrome name sometimes marked on the hangars or field of civil aerodromes may provide a positive pin-point when all else fails. The identification letters are usually the first and last letters of the place name so that, even if the airfield is not marked, it may be recognized by the letters corresponding to a town within the area of uncertainty. Sometimes, the types of aircraft on the airfield provide the final clue when there are several aerodromes close together and the pilot has some idea of the types of aircraft used at the aerodromes.

When it is required to fly back on to track, the change in course must always be much more than the angle of the track error since changing course by that angle brings the new track parallel with the original one.

It is useful to note that an error of one mile off track in sixty miles distance is the same as one degree track error. This is known as the one-in-sixty rule for estimating angles, and it can be used very easily for measuring angles on maps.

For example, five miles off track in thirty miles is an angle of ten degrees; two miles in ten miles is an angle of twelve degrees.

$$\text{Track error} = \frac{60}{\text{distance in miles}} \times \text{error in miles}$$

It is not suggested that track errors should be calculated accurately in flight, but some knowledge of the alteration of course needed for getting back on to track will prevent wild estimates which waste valuable height.

In conclusion, finding your way in the air will be easier if you:

1. Plan the flight thoroughly and prepare a flight plan and maps. Note the course required allowing for the wind velocity and variation.
2. Study the map and try to memorize the main pin-points.
3. Keep the map correctly orientated.
4. Read the map first and then look on the ground for the features shown, unless lost.
5. Note each pin-point and the time on the map or log.
6. Never rely on a single feature unless it can be confirmed by others in the area or is an indisputable natural feature such as coast line, large lake, river or range of hills.
7. Never try to account for every minor feature seen on the ground or keep an exact pin-point all the time.
8. If uncertain of the position, work from the last reliable pin-point, check the time elapsed and search the circle of uncertainty round the estimated position on the map. Keep on the same course.
9. When uncertain of your position note the features on the ground and then look for similar ones on the map. Never guess or jump to conclusions.
10. Never let the map reading interfere with the soaring; it is more important to keep up.

CHAPTER 28

GOING FASTER AND FARTHER

Factors governing cross-country performances—Cruising technique—Gliding to a goal—Calculating the best speeds to fly between thermals

THE average glider pilot will find his time fully occupied with the problems of staying up and map reading during his first few cross-country flights. However, as he becomes more experienced and sets himself more difficult tasks, he will want to travel faster.

It is difficult to make a long distance flight in this country because Great Britain is so small. Also, even in the summer time it is unusual for the weather to be soarable before 10.30 a.m. or after 6.30 p.m. and it is even more unusual for these conditions to exist for 200 or 300 miles. The aim of the glider pilot must be to travel as fast as possible to make the most of the good thermals while they are available.

The pilot attempting a long distance flight must normally set off as soon as he can be fairly sure of staying up. However, if a short flight is planned, the pilot can choose his time. An early start will waste time because the thermals will be weaker and it may be difficult or impossible to stay up: whereas by waiting until conditions appear ideal there is always the risk that the weather will deteriorate later in the day making the task impossible.

The most important factor affecting cross-country performance is the ability of the pilot to find and make the best use of the strongest lift for climbing. This is largely a matter of practice.

Unless there are other gliders climbing in the same thermals or attempting the same task it is difficult to judge the efficiency of the individual pilot. The expert is constantly striving to improve the rate of climb by exploring the extremities of his thermal for even stronger areas of lift. Frequently a small change in position of the circle will double the rate of climb and since nearly half the flight is spent climbing, this improvement will mean a much greater distance covered.

It is just as important to avoid flying through strong downdraughts as it is to climb well in the thermals. This is largely a matter of experience in judging whether a particular cloud is still growing, and it is useful to watch the clouds and also gliders soaring to learn to distinguish between good and bad clouds.

The strength of the thermals may vary considerably and the pilot must select the strongest ones if he is aiming to fly a long distance. Unless the glider is desperately low, the search for stronger lift should be continued if a thermal does not come up to expectations after several circles. Similarly, if the thermal becomes weaker with height it should be left, provided that there is good prospect of finding another stronger one. On some days the lift is much stronger in the clouds and it will pay to keep above cloud base as much as possible. At other times the strongest lift will be found well below the clouds and it will be most efficient to work much lower down.

Whereas the beginner is advised to try to stay as high as possible in order to avoid a premature landing, the would-be expert must be more critical of the thermals he uses, and be prepared if necessary to descend much lower in search of the stronger lift. If he is careless or too critical, or if he fails to realize that the conditions ahead have deteriorated, his urge for better lift and more speed will result in a landing. In this case he would have flown farther by cruising more carefully and conserving height at all cost.

The performance achieved on a particular day depends to a great extent upon the efficiency of the glider. A good pilot in a low performance glider may well be easily beaten by a high performance machine even flown by an inexperienced pilot. It seems probable that gliding competitions in future (at least in the international field) will be for restricted classes of gliders so that the results will depend upon the skill of the pilot rather than the design of the glider.

CRUISING TECHNIQUE

Thermal soaring can be considered in its simplest form as a series of units of a glide and a climb. The average speed across country (ignoring the effect of the wind) depends mainly upon the average rate of climb in the thermals. However, particularly when the thermals are strong, a significant improvement in average speed can be made by cruising between thermals faster than the speed for the best gliding angle.

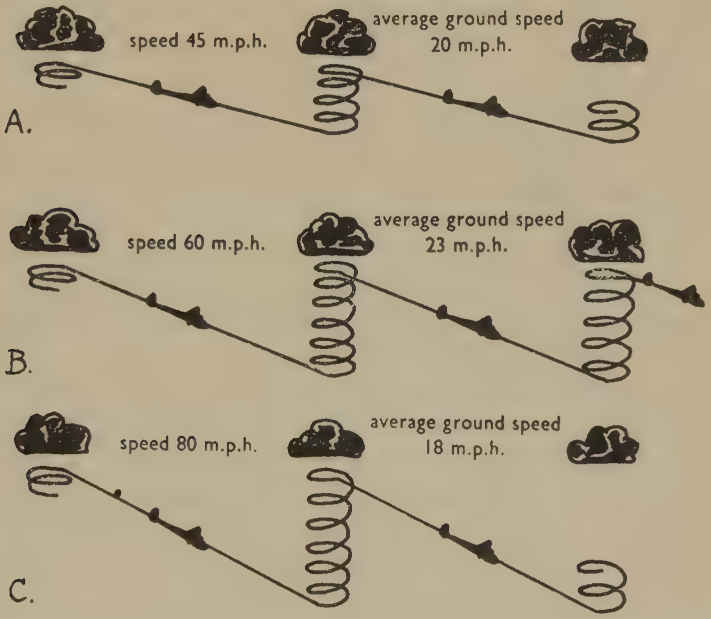

speed 45 m.p.h.
average ground speed 20 m.p.h.
A.
speed 60 m.p.h.
average ground speed 23 m.p.h.
B.
speed 80 m.p.h.
average ground speed 18 m.p.h.
C.

Fig. 70. The results of flying at different speeds between thermals. A. flying too slowly. B. the best cruising speed. C. flying too fast. (The speeds refer to Skylark 2 achieving an average rate of climb of 2 feet per second in no wind conditions.)

Fig. 70 shows a practical example. Flying at the speed for best gliding angle, less time is spent in gaining height but this is offset by the slower speed in straight flight. At the "best cruising speed" a greater number of thermals have to be used but the average speed over the ground is raised. On a poor soaring day, there is little to be gained by this technique which assumes that the next thermal will be found. The moment that assumption cannot be made it will pay to reduce speed and conserve height.

The cruising speed between thermals should be based on the strength of the *next* thermal. Otherwise, following a rapid climb, the pilot might jeopardize his chances of staying up by cruising at high speed into an obviously poor thermal area. In good conditions it is usual to assume that the next thermal will be as strong as the previous one. The speed to fly between thermals can then be based on the rate of climb obtained in the last thermal. However, the pilot must be prepared to slow up and change his technique the moment that there is any doubt about the next thermal.

Cruising at too high a speed between the thermals will reduce the average speed across country by making it necessary to climb more often. The "best" cruising speed can be calculated from the performance curve of the particular glider.

During a flight the pilot must decide how low he is prepared to descend before slowing down and changing to a "staying up at any cost" policy. He must also decide what strength of lift he is prepared to discard in the search for the best thermals. On a summer day with the cloud base at 5,000 feet, it would be reasonable to cruise at the optimum speed down to 2,500 or 3,000 feet, i.e. about half the height of the cloud base. From then on the pilot would be well advised to slow down and concentrate upon finding a thermal to keep him up. The lower the glider gets, the weaker the thermal strength which is acceptable. For example, the pilot may decide that on a particular day that he will only use thermals which give at least 10 feet a second if he is above 4,000 feet, 5 feet a second if he is above 3,000 feet, and anything he can find below 2,000 feet.

The speed to be flown between thermals will also have to be varied when the glider flies through rising or sinking air. It may be possible to cruise for many miles without losing height by diverting to fly under a cloud street. This will avoid the necessity of circling to gain height and will therefore increase the average ground speed considerably. In this case, and at any time when the glider is flying through rising air, the cruising speed should be reduced. Similarly when flying through areas of sink, the speed should be increased until more favourable conditions are found.

It is impossible to determine the average strength of down draughts between thermals, because in unstable conditions the air is alive with varying movements. Since the speed should be varied according to conditions, the usual arrangement is to have a second scale alongside the variometer to show the pilot the correct speed to fly for the rate of sink which is indicated at the time.

The best cruising speed for flying between thermals depends on the average rate of climb, and the rate of descent of the air between them. Wind strength and direction is immaterial although it will, of course, affect the average speed over the ground. Once the glider is in free flight it can be considered as being in free flight in the air mass. The aim is to achieve the best progress through the air mass since that will give the best ground speed regardless of the wind strength and direction.

If the lift is weak, the average cruising speed will be low, and a flight against a strong wind will be slow or impossible. If the glider is flown at the best cruising speed and makes no progress against the wind during a complete cycle of climb and descent, nothing can be done to remedy the situation unless the strength of the lift increases. An improvement of a few miles per hour in the average cruising speed through the air mass will make all the difference between getting nowhere and making headway against a strong wind.

Owing to the variations in the rate of climb in a thermal, it is difficult to assess the average rate of climb exactly by reading the variometer. The rate of climb indicated by the variometer is usually much greater than the average measured by the gain of height timed with a watch. Often considerable time is wasted in getting into the best part of the lift and this reduces the average rate of climb considerably.

An average rate of climb of over 10 feet per second is unusual except when cloud flying, even though the readings on the variometer may seem to be between 10 and 20 feet per second all the time.

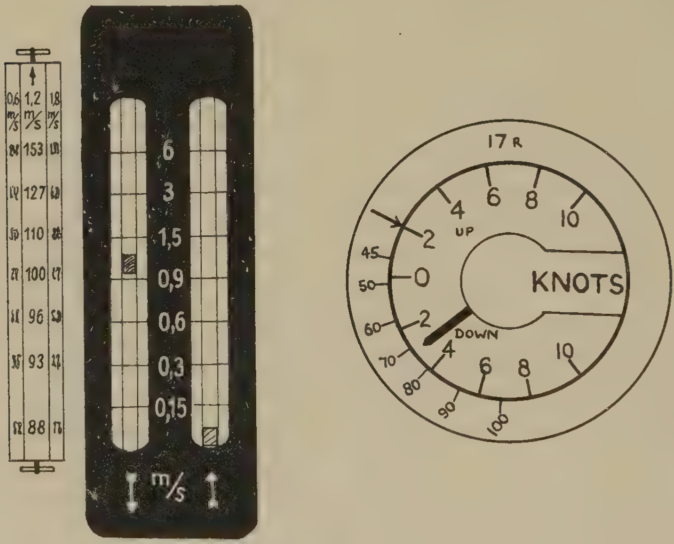
It is useful to time the height gained in thermals with a stop watch to obtain a better idea of the real rates of climb and how they compare with the readings of the variometer. This will also make the pilot painfully aware of the time wasted by poor centring and using weak thermals.

Some pilots time all their climbs, but this is an unnecessary burden as with practice a satisfactory approximation can be made from the variometer readings. Most skilled pilots achieve rates of climb of a half to three-quarters of the average variometer reading.

When the lift is rather broken, it often takes time to realize that although the variometer is flickering to very high rates of climb, the actual achieved rate is quite low. A better assessment can be made by watching the altimeter. The hand will be moving steadily if the lift is really worth while.

With a dial type variometer such as the Horn or P.Z.L., a circular sub-scale can be mounted round the face of the instrument and calibrated in speeds to fly. The sub-scale can then be turned to point to the average rate of climb expected and the position of the needle will then indicate the best speed to fly at any given moment.

At high altitudes most types of variometer over-read because of the reduced density of the air. This can be allowed for when compiling the tables or by flying a little slower than they indicate. The error is about 10 per cent per 5,000 feet.



Speed to fly scales.

Fig. 71a. A Cosim variometer. Fig. 71b. A vane type variometer.

In the case of two-seater gliders, the effect of reducing the all-up weight when flying solo can be allowed for by flying a few miles an hour slower than the calculated best speeds for full load.

Near the top of each climb, the pilot should try to assess the strength of the next thermal and set his "speed to fly" scale to the appropriate rate of climb. As soon as the rate of climb drops off seriously, he should leave the thermal, increasing speed to his best cruising speed and varying it according to whether he is flying through sinking or rising air until the next area of strong lift is encountered.

If the glider flies slowly into an area of strong sink, several hundred feet may be lost while gaining speed and reaching better conditions. It may often conserve height and improve the average cross-country speed to increase flying speed in anticipation of the down-draughts usually encountered just after leaving the thermal, or before passing through or near to clouds which are obviously decaying.

Cruising at high speeds a small reduction in the rate of descent may not be appreciated as being caused by rising air. When interpreting the readings of the variometer the normal rate of descent at the speed must be borne in mind, because, even in strong lift, the variometer will show descent if the glider is flying at high speed. For example, flying at 65 m.p.h., the normal rate of descent on a Skylark 2 would be about 4 feet per second and a reading of less than that amount would indicate the presence of rising air. The decision on whether to circle immediately or to slow down and fly on would depend on how strong the lift seemed to be and on whether the pilot is anxious to gain more height.

Unfortunately, the correct speeds to fly have to be found by a series of approximations. For example, if the speed to fly ring shows that the cruising speed should be 60 m.p.h., as the speed is increased to that figure, a higher rate of sink will be indicated together with a faster cruising speed. After several corrections the two will eventually coincide, but the process of adjustment must start again as soon as a new air mass is reached.

This problem can be avoided if the variometer shows up and down movements of the air instead of the climb and descent of the glider.

A simple but satisfactory method is the MacCready leak. Air is led from a pitot head through a fine, adjustable needle valve to the capacity side of the variometer. By careful adjustment flying in stable conditions, a setting can be found to make the variometer read zero over the range of speeds most used between thermals. (As the speed is increased, more air flows through the valve maintaining the zero reading in spite of the greater rate of descent.) Used with total energy, this system gives a continuous indication of what the surrounding air is doing and what cruising speed should be flown.

Unfortunately false readings in turns make a second instrument

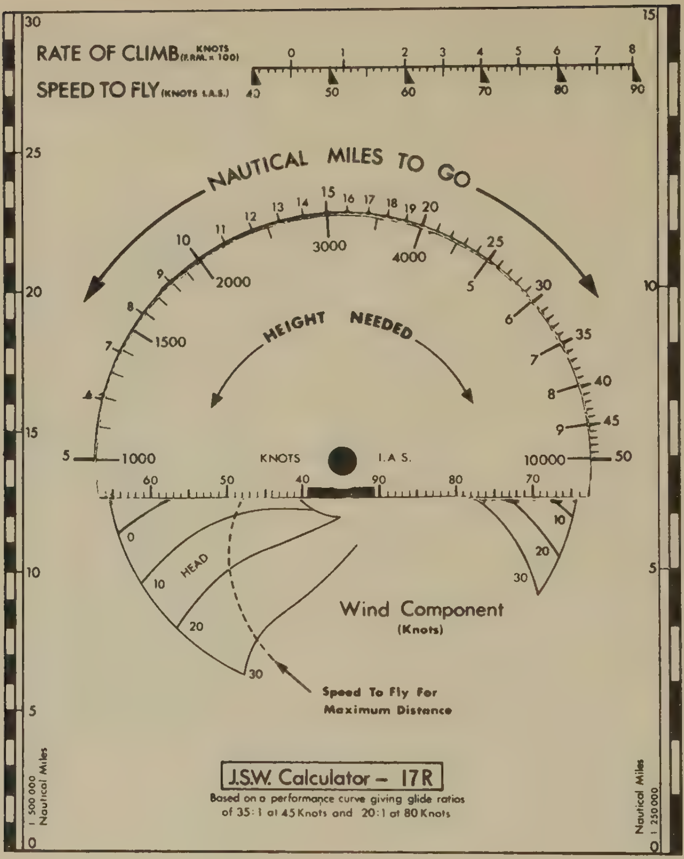

RATE OF CLIMB (KNOTS F.P.M. × 100)
SPEED TO FLY (KNOTS I.A.S.)
NAUTICAL MILES TO GO
HEIGHT NEEDED
KNOTS I.A.S.
HEAD
Wind Component (Knots)
Speed To Fly For Maximum Distance
J.S.W. Calculator – 17R
Based on a performance curve giving glide ratios of 35:1 at 45 Knots and 20:1 at 80 Knots
1:500 000 Nautical Miles
Nautical Miles 1:250 000

Fig. 72. Gliding to a goal using the John Williamson Calculator.

(1) Measure or estimate the rate of climb and read off the speed to fly on the top scale.
(2) Set this speed against the wind speed curve by turning the centre piece.
(3) Measure the distance to fly and read off the height needed against the miles to go scale.
(4) Add allowances for the height of the goal and for down-draughts.
(5) Check the distance to go and height required at each pin-point.

Example. Rate of climb 2 knots, distance to goal 28 nautical miles, height of goal 600 feet, weak thermals and down-draughts.
Best speed is 60 knots. Height needed 5,500 feet.
Safety margin, say 500 feet. Indicated height required 6,600 feet minimum.

essential for centring. Also the pilot must never forget that at least 3 feet per second of lift is needed even to maintain height and more for a reasonable climb.

GLIDING TO A GOAL

In competition flying, the problem of knowing how high to climb for the final glide to a goal can be crucial, since time spent climbing higher than is necessary can never be made up by flying at a higher speed. On other occasions it can also be important, since it is easy to waste time and height searching for further lift, perhaps unsuccessfully, when in fact the goal had been within gliding range. The incredibly flat gliding angles of modern gliders make the judgment of these long straight glides almost impossible without a calculator. Even then the glide can be completely upset by a change in wind strength or an unexpected area of sinking air.

Simple calculators can be bought or made to suit the performance of the particular glider. (Fig. 72.)

The last climb should be just high enough to allow a straight glide at the best cruising speed based on the strength of the last thermal. Depending on the conditions, some spare height must be allowed, but this can be whittled down during the last few miles by flying a little faster. As the glide progresses, the height and distance to go must be checked by getting accurate pin-points, and an early decision must be made to find more lift if there is any doubt about reaching the goal. Normally the final glide speed will be well above the speed for best range, and unless there is a strong headwind it is possible to extend the glide slightly by slowing down to that speed.

It is usually worth calculating the heights required to reach the goal from several convenient pin-points on the map in case cloud flying makes it difficult to use the calculator in flight.

If during the final climb the strength of the lift increases as height is gained, the calculator should be reset to the higher rate of climb and enough height taken to fly faster to the goal.

Even a small layer of ice on the leading edges of the wings will ruin the gliding performance. The cruising speed should be cut down and an allowance should be made for the gliding angle being reduced by about a third. Since the ice takes considerable time to melt, it does not pay to risk icing unless the rate of climb in the clouds is very good and a large gain of height is possible.

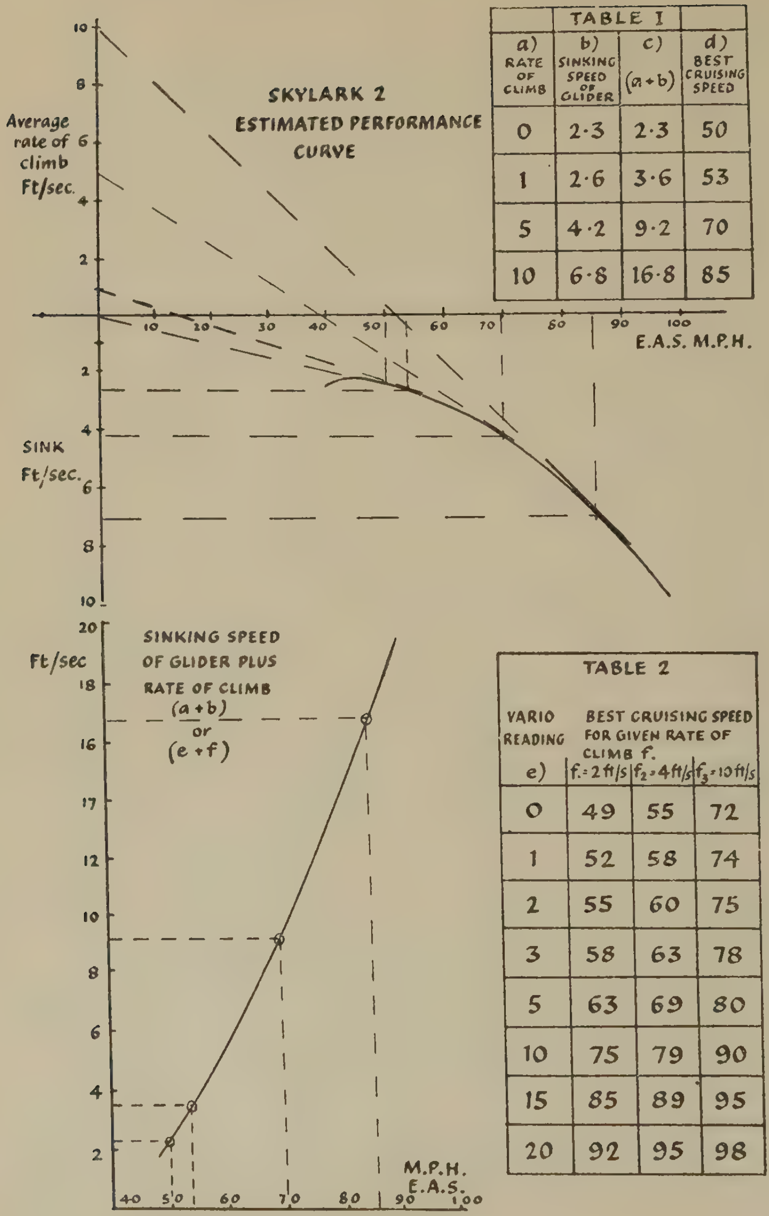


TABLE 1

a) RATE OF CLIMB	b) SINKING SPEED OF GLIDER	c) (a + b)	d) BEST CRUISING SPEED
0	2·3	2·3	50
1	2·6	3·6	53
5	4·2	9·2	70
10	6·8	16·8	85

TABLE 2

VARIO READING e)	BEST CRUISING SPEED FOR GIVEN RATE OF CLIMB f. f_1 = 2 ft/s	f_2 = 4 ft/s	f_3 = 10 ft/s
0	49	55	72
1	52	58	74
2	55	60	75
3	58	63	78
5	63	69	80
10	75	79	90
15	85	89	95
20	92	95	98

Fig. 73. Calculating the best cruising speeds to fly between thermals.

CALCULATING THE BEST SPEEDS TO FLY BETWEEN THERMALS

The cross-country performance of a particular type of glider depends on it having a flat gliding angle at high speeds as well as a low rate of sink when circling.

A high performance glider properly flown will always out-range one with a poor gliding angle, even though the latter may be able to out-climb it in a thermal.

The theoretical best speeds to fly can only form a basis for the pilot to work on and will be little help if the pilot is poor at thermal soaring.

The first essential for determining the best speeds to fly between thermals on cross-country flights is an accurate performance curve for the type of glider. If no flight tests have been carried out, the estimated performance curve produced by the manufacturer can be used. These are often optimistic but may be modified slightly to make allowance for this fault.

The performance curve should then be drawn on to a large sheet of graph paper so that all the required measurements can be made without the need for re-drawing it several times.

A series of tangents are drawn to the curve for a few chosen rates of climb (Fig. 73.) Where the tangents touch the curve corresponds to the best cruising speed between thermals for each rate of climb.

These cruising speeds make no allowance for flying through rising or sinking air. Some pilots vary their speed by rule of thumb methods such as adding or subtracting about 10 m.p.h. when the glider is in sink or lift. Others prefer to have a more definite method to work on, and calculate the correct speeds as follows:

In table 1:—

a is the rate of climb, *b* is the rate of sink of the glider at the particular cruising speed, *c* is the sum of *a* and *b* and *d* is the best cruising speed as found from the curve.

Next draw a graph to show *c* against airspeed.

From this graph, table 2 can be compiled for convenient rates of climb *f* 1, 2 and 3. The rates of sink *e* should be the same as those marked on the variometer.

The best speeds to fly are found by plotting *e* plus *f* on the vertical axis of the graph and measuring the corresponding speed on the airspeed axis.

These speeds are the best cruising speeds for the appropriate rate of climb *f* when the variometer is reading any given rate of sink *e*.

For example, if the average rate of climb *f* is 4 feet per second, when the variometer reads 3 feet per second down the glider should be flying at 63 m.p.h. (63 m.p.h. is the speed corresponding to 4 plus 3 feet per second on the vertical axis of the graph).

If the variometer shows a higher rate of descent, the speed should be increased until the speed and rate of sink on the scale correspond.

If the position error is significant, the airspeed axis of the graph should be re-scaled so that all speeds in table 2 are indicated airspeeds and need no further corrections. The E.A.S. (Equivalent Air Speed) is the I.A.S. (Indicated Air Speed) assuming no instrument or position errors.

Table 1 can then be used to calibrate a speed to fly ring or for a calculator.

The average cross-country speed in stable air not allowing for the effect of any wind can be found from Fig. 73 by noting where the tangent for the particular rate of climb cuts the airspeed axis. For example, an average rate of climb of 5 feet per second gives an average cross-country speed of 40 m.p.h. assuming that there is no rising or sinking air between the thermals.

APPENDIX I

GLIDING AWARDS AND RECORDS

NOTHING encourages an enthusiastic sportsman so much as keen competition and a sense of pride in personal achievement. This is particularly true of gliding in which the award of certificates and badges, which are recognized all over the world, has played a great part in the encouragement of a healthy competitive spirit amongst both beginners and expert pilots.

Unlike most club or society badges, a gliding badge is an award for actual ability and achievement. It cannot be bought by money or prestige alone but must be earned by skill, adventure and, in some cases, endurance.

Gliding is an international sport, and the regulations for world records and the tests for the Silver, Gold and Diamond "C" badges are laid down by the Federation Aeronautique Internationale who also control record flights for powered aircraft.

The requirements for the "A", "B" and "C" certificates vary from country to country and are determined by the National Aero Club or Gliding Association of the country concerned.

In some countries, the "C" certificate test includes examinations in Principles of Flight, Meteorology, Navigation and Flying Regulations, and is a glider pilot's licence.

British gliding suffers far fewer restrictions and regulations than most of the Continental countries and no licence is required by law. Pilots who have "C" or Silver "C" certificates are granted certain concessions if they wish to become private (powered aircraft) pilots and can count some of their gliding experience towards the hours needed for their licence.

The requirements for the various certificates are as follows:

"A" Cert. One satisfactory circuit flight solo.

"B" Cert. Two more satisfactory circuit flights solo during which the pilot demonstrates the ability to make satisfactory turns in both directions.

"C" Cert. A soaring flight during which the glider maintains (or gains) height for at least five minutes.

The pilot must also pass a test on the Laws and Rules for Glider Pilots.

B.G.A. Bronze "C". This is the minimum qualification for a glider pilot to fly out of gliding range of his base.

He must have 50 solo glider flights (or at least 50 hours PI on powered aircraft and 20 solo glider flights) and 2 solo soaring flights of at least 1 hour after release from aerotow (max. height 2,000 feet), or 30 minutes from wire or bungee launches, followed by normal landings as briefed.

In addition there is a flying test which includes stalling and incipient spins and simulated field landings. The written test includes a general paper on Airmanship, Principles of Flight, and Meteorology, together with the test on the Laws and Rules for Glider Pilots (as for the "C").

F.A.I. SILVER "C"

Duration. A flight of not less than five hours.

Height. A flight in which the gain of height registered by the barograph is not less than 1,000 metres (3,281 feet). Gain of height being the difference between the maximum height recorded and the lowest previous point registered after release.

Distance. A flight of not less than 50 kilometres (31.07 miles) carried out in a straight line.

The loss of height between the release and the place of landing must not exceed 1 per cent of the distance covered. (Also see Fig. 69.)

F.A.I. GOLD "C"

Duration. A flight of not less than five hours.

Height. A flight in which the gain of height registered by the barograph is not less than 3,000 metres (9,843 feet).

Distance. A flight of not less than 300 kilometres (186.42 miles) carried out in a straight line, a broken line of not more than 2 legs, a triangle, or an out and return.

Turning points must be declared in writing before take off. (Also see Fig. 69.)

DIAMONDS

The holder of a Gold "C" badge is entitled to wear a diamond on the badge for each of the following performances:

Height. A gain of height of 5,000 metres (16,405 feet).

Goal flight. A flight of at least 300 kilometres (186.42 miles) to a fixed point declared before take off.

Distance. A flight of at least 500 kilometres (310.7 miles).

Both Goal and Distance flights may be made in a straight line, a broken line of not more than 2 legs, a triangle or an out and return. Turning points must be declared in writing before take off. (Also see Fig. 69.)

With all triangular flights, no side may be less than 28 per cent of the total distance.

With the F.A.I. badges, any flight may count for Silver, Gold and Diamond awards; not more than two tests can be attempted in any one flight except for the Diamonds, which can all be awarded for one flight; the flights must be made solo and a sealed barograph must be carried on all the flights. (Copies of the full regulations can be obtained from the B.G.A.)

National and International gliding records are divided into two main classes, solo flights, and flights made by two or more persons flying together. There is also a separate category of records for women.

In each class there are records for distance, out and return flights, distance to a pre-determined goal, speed over triangular courses and set distances, and absolute and gain of height. Until 1955 there were also duration records but these had become feats of endurance and because of the danger of the pilots falling asleep at the controls they have been discontinued. In the early days of gliding long duration flights had great publicity value and served some purpose in investigating soaring conditions at night. But flights of over forty hours, nowadays, can have little real value, and serious harm is caused if an accident occurs on such a flight.

Note. For Silver, Gold and Diamond "C" flights made round triangular courses, the shortest leg must be at least 28 per cent of the total distance flown.

APPENDIX 2

THE GLIDING MOVEMENT IN GREAT BRITAIN

THE British Gliding Association is the central body representing the gliding clubs and associations in Great Britain. The Headquarters of the B.G.A. are at 75 Victoria Street, London, S.W.1, and it is able to answer any inquiries about the gliding clubs and courses of instruction.

There are gliding clubs in most parts of the country and these are expanding and increasing in number each year. Most of the larger clubs have full time instructors and ground engineers, and operate throughout the week. The smaller clubs are usually run on an entirely voluntary basis and fly mainly at weekends and holiday periods.

The three services have their own gliding clubs and gliding is a recognized sport. Their aim is to provide gliding facilities for all ranks at a low cost.

There is also the Air Training Corps scheme which trains cadets to glide. Approximately twenty gliding schools operate at aerodromes throughout the country and train many thousands of boys up to solo standard. These schools are run mainly by unpaid volunteer instructors and R.A.F.V.R.(T) officers. Unfortunately this training is not sufficiently advanced to inspire many boys to join a gliding club and continue to glide, or for that matter to join the R.A.F. It is, however, of very real value to the country as a whole in spreading airmindedness and in developing the character and spirit of adventure of the boys. There is no doubt that far more value could be derived from this gliding if the training were to be continued to include soaring flights.

Training throughout the clubs and associations affiliated to the B.G.A. is carried out on dual control, two-seater gliders; the "solo" method of training having been abandoned many years ago.

Most of the larger clubs run training courses for beginners lasting one or two weeks and these are an excellent way of spending a holiday and finding out whether you enjoy the sport.

The membership fees for most gliding clubs are about eight guineas a year and there is usually an entrance fee of about eight guineas. However, many clubs have reduced rates for members who live a long way from the club.

*Flying fees are five to ten shillings a launch by winch or motor car, and an additional fifteen shillings an hour is charged for soaring flights. Launching by aerotow costs twenty to thirty shillings for a launch to 2,000 feet.

Most clubs have their own catering and sleeping facilities and encourage their members to stay at the club at weekends. Flying often takes place from dawn to dusk and the keen pupil can get extra flying by making an early start.

The cost of gliding is kept relatively low by the voluntary work of the club members themselves. In the smaller clubs almost all the glider and vehicle maintenance is carried out by members and everyone is expected to lend a hand with some aspect of the club life.

Gliding is by no means only a rich man's sport. There are people from every walk of life and every income group at a gliding club. This is one of the attractions of joining a club which can be enjoyed even by an associate member.

What of the future? It now seems clear that special light aircraft designed to simulate the characteristics of modern gliders will be introduced to provide quicker and perhaps more economical training. In addition there will be self launching, powered gliders capable of good soaring performances for those enthusiasts who live too far from a gliding club or who cannot spare the time for normal gliding.

---

*All fees and costs in this chapter refer to 1966 and, of course, include all instruction and the use of the club glider.

APPENDIX 3

OWNING YOUR OWN GLIDER

MEMBERS place their names on a flying list and take turns to fly club gliders so that, if they arrive late in the day, they may be unable to fly until the evening when there is no hope of thermal soaring. The advantages of owning your own glider are, therefore, obvious.

There is nothing, legally, to prevent any enthusiast from building and flying a glider of his own design if it is insured against third party risks and is not flown at a recognized gliding site. However, if it is to be flown at a club site, it must have a Certificate of Airworthiness.

The Technical Committee of the British Gliding Association is responsible for the testing of new types of British gliders to ensure that they have safe flying characteristics and are structurally sound. It also issues Certificates of Airworthiness which are valid for twelve months.

Very few gliders have been constructed by amateurs in this country since 1950, whereas on the Continent, it is common for people to build their own gliders or to assemble gliders from kits of parts. This is a lengthy business requiring considerable skill in carpentry and a full understanding of the principles of wooden aircraft construction.

Most enthusiasts who want to have their own glider prefer to buy a proven design.

The choice of design will depend mainly upon how much the prospective owner can afford. A new high performance machine will cost over £1,500. This is clearly beyond the means of the average enthusiast. However, pre-war gliders such as the Kite, Gull and Tutor occasionally change hands for £50 to £200 and are capable of good soaring flights.

Although the initial cost of a new glider is high, it is a reasonable investment if it is well cared for and flown regularly. The capital depreciation is small and the market for modern second-hand gliders is growing rapidly as gliding becomes more popular.

A trailer is essential, but it may be either the open frame type or a completely weather-proof closed one. An open trailer is quite satisfactory for retrieving, provided that a dry garage or hangar is available to store the glider.

It is also desirable to possess a car which is suitable for towing the trailer. An 8–10 h.p. car can be used for a small glider, but at least 12–24 h.p. is necessary for long journeys in hilly country.

The names and addresses of glider manufacturers in Great Britain, and details of second-hand machines for sale, are to be found in the gliding magazine *Sailplane and Gliding*.

In general, the higher the performance of the glider, the easier it is to fly and the less likely it is to be damaged by an error of judgement on the part of the pilot. Even if the pilot does not aspire to cross-country flying, it is worth buying the machine with the best possible performance.

All modern British gliders are structurally sound and have good handling qualities in the air. The choice is largely one of price and performance.

Expert advice should be sought when buying a glider of foreign design as standards of airworthiness vary considerably. Many are fitted with inadequate air brakes for landing in small fields. British standards of stability and control are high, and some Continental machines would be considered unsafe by these standards.

Many gliders are available with either a fixed landing wheel or a detachable "dolly". A competition pilot will usually choose the detachable "dolly" for the improved performance and the shortened landing run on the skid. However, a fixed wheel is much more practical for normal flying as it avoids the annoyance of having to lift the glider to refit the wheels before it can be moved off the landing area.

The choice between a single-seater and two-seater is a personal one. A two-seater can, of course, be flown solo but in practice some people do not feel inclined to do this. It is a great pleasure to be able to take friends for flights, but many pilots find that both they and their passengers are prone to airsickness when they are not actually handling the controls. Also it is surprisingly difficult to agree amicably about sharing the flying. Most pilots, like yachtsmen, have their own ideas on how things should be done and are not content to sit and watch for very long. In my experience, there is nothing more agonizing than watching another pilot "fumbling" and wasting opportunities on a really good day.

There are many advantages in sharing a glider and most privately owned machines are shared by a syndicate of from two to six people. This makes operating and ground handling easier, and reduces the initial outlay and running costs. The success of any syndicate depends upon the personalities of the members, and the greatest care is required when selecting possible members.

If any members of the syndicate are abnormally tall or large, the size of the cockpit has to be considered when choosing the glider. Long flights are much easier when the pilot is comfortable and able to relax in the cockpit.

RUNNING COSTS

The major annual expenses for the private owner are:

Third party insurance for at least £5,000 (premium about £8).

Comprehensive insurance against accident (optional).

Certificate of Airworthiness inspection (known as the C. of A.).

The third party insurance is compulsory for all gliders, but most owners also insure comprehensively against accident. The premium for a comprehensive insurance depends almost entirely upon the record and experience of the pilot or pilots who will be flying the glider. Insurance for a few, named, pilots, is much lower than for a club machine which will be flown by any club member.

The cost of comprehensive insurance for a glider and trailer valued at £500 (such as a second-hand Olympia) shared by four pilots of Silver "C" standard would be about £35 p.a., i.e. 7 per cent of its value per annum.

However, the insurance companies are very fair with owners who have no accidents and will reduce their premiums considerably. It is normal for the pilot to pay the first £25 of any claim.

The cost of the C. of A. inspection depends entirely upon the amount of work required to make the glider fully serviceable for another year. The cost can be reduced if the owner does most of the work himself under the supervision of a B.G.A. approved inspector. This is possible at most gliding clubs, which usually have workshop space available for private gliders.

Briefly, a C. of A. inspection involves cleaning and inspecting the whole glider, replacing any damaged or worn parts, and making good any temporary repairs and patches.

Assuming that the glider is only a few years old and that there are few outstanding repairs or replacements to be made, the cost of the C. of A. carried out professionally might be between £20 and £50. However, every seven years or so the wings and tail surfaces may require recovering with fabric and the whole glider re-finishing to protect the structure. This is costly because of the large amount of work involved, and may raise the cost of a C. of A. to over £150.

Apart from the annual C. of A. inspection it is usual for the pilot to carry out a thorough inspection of his glider after rigging it and before the first flight of the day. Most private owners will also carry out minor repairs and fabric patches themselves, but send the machine away for repair if they are unfortunate enough to damage it seriously.

The life of a wooden glider seems to be at least twenty years and depends mainly upon the state of the glue joints. Gliders built before 1945 were usually glued with casein glue, whereas all modern ones use Aerolite, a synthetic resin.

Casein glue has a rather unreliable life. There are many casein glued gliders over twenty years old in which the glue is perfectly sound. However, if it remains very damp for a long period it develops a bloom and eventually goes bad. This can be detected by the bad smell of rot. Extensive inspection and rebuilding is necessary where the glue is suspect and often the glider proves beyond economic repair.

Gliders built with Aerolite should last almost for ever, since the glue is oil- and water-proof and does not deteriorate with age. However, particularly in warm climates, the wood gradually dries out and becomes more brittle. This reduces the strength of the glider until eventually it is no longer airworthy. Wood shrinkage in hot climates will also reduce the strength of the glued joints.

INDEX

Aerobatics, 87, 126, 127, Plate 5
Aerofoil, 85, 86
Aerotow, 106–17
Aileron, 15, 16, 19–22
Aileron drag, 26, 65–68, 88, 92
Air brakes, 6, 30, 41–44, 75, 91, 96, 98, 211, 214, 215, 219
Airspeed indicator (A.S.I.), 6, 34, 87, 187, 215
Altimeter, 6, 28, 41, 171, 172, 190
Angle of attack, 69, 85, 86, 88
Anoxia, 223–6
Approach, 28, 40, 41, 45, 46, 97, 98, 102–4, 177–81
Artificial horizon, 6, 202–4, 217, 218
Attitude, 17, 45, 98
Auto-rotation, 88
Axis of movement, 15, 16

Ballooning, 29, 30
Bank, 15–19, 61, 65
Barograph, 115, 182, 204, 234
British Gliding Association, 7, 8, 57, 253–4
Bungee, 2

Cable breaks, 23, 26, 52–56
Cable make up, 11
Cable parachute, 11, 52
Centering, 146–50
Centre of gravity (C. of G.), 90
Certificates, 57, 58, 157, 204, 206, 230–2, 251–3
Certificate of Airworthiness, 256–9
Chandelle, 127
Circuit procedure, 38–51
Clothes, 8
Cloud streets, 152, 242
Cockpit layout, 4–6
Compass, 6, 119, 198–202, 215–17
Controls, 6, 15
Cook compass, 202
Co-ordination, 17–20, 65–68
Cosim variometer, 191–2, 244
Cost of gliding, 253–7
Courses of instruction, 7, 254
Cross country flying, 168, 170–86, 229–49
Cross wind landings, 81–84
Cruising speeds, 121, 122, 240–9
Cumulus cloud, 130–2, 207, 240
Curl over, 106, 153, 160–3

Declaration, 232, 252
Derigging, 182
Deviation, 199, 200
Diamonds, 231, 253
Differential ailerons, 67
Down currents, 49, 98, 99, 102, 124, 125, 155, 159, 161, 165, 168, 216, 240, 245
Downwind landings, 163–4
Drag, 18, 61–63, 85, 86, 88, 121
Drift, 26, 81–84, 102, 103, 233, 237
Dropping wheels, 80, 257

Elevator, 15, 16, 68–70, 90
Equivalent Airspeed (E.A.S.), 189, 248, 249
Estimated performance curves, 122, 247, 248

Fields, 160, 174–9
Field landings, 42, 160, 170–86
Final glide to a goal, 246–7
Final turn, 28, 40, 42, 43
Fishtailing, 74–75
Frise ailerons, 67

"g", 64–65, 87
Gliding angle, 71, 121–3, 245–6
Goal flights, 230, 245–6, 252–3
Gold "C", 230, 252–3
Ground handling, 2–4, 95, 181–2
Plates 4 and 7

Hail, 116, 210, 219, 221
Harness, 5
Hill lift, 153–4

Hill soaring, 153–64
Hyperventilation, 222

Icing, 67, 210, 219–21, 227, 246
Incipient spins, 33, 80, 87–89, 214
Indicated airspeed (I.A.S.), 87, 189, 249
Instruction, 7
Instruments, 6, 187–206, 212
Instrument flying, 150–1, 207–22
Insurance, 257

Judgement, 28, 39, 45, 103, 179–81

Laminar flow, 70–71
Landing, 28–30, 44, 81–84, 98, 170, 171, 177–81
Landing certificate, 182, 186
Launch,
  aerotow, 10, 106–17
  bungee, 2
  motor car, 3, 7, 10, 23, 26–27, 52–53, 76–80, 99, 144
  winch, 2, 7, 10, 23–25, 52–53, 76–80, 99, 144
Lee wave, 165–7
Lenticular clouds, 165–8
Lightning, 221
Loading in turns, 64–65
Local soaring, 118–20
Log book, 8
Loop, 87, 126
Lost, what to do when, 236–7

Maps, 118, 230–3
Map reading, 118, 229–34
Minimum sinking speed, 70–71, 121–3, 143

Navigation, 229–38

Olympia, 118, 258
Ottfur release, 10, 25
Ottfur rings, 11
Out and return flights, 230, 252–3
Over run, 13, 52–53
Oxygen, 169, 210, 223–8

Parachute, 90, 211, 227
Penetration, 103–4, 151, 163
Performance curves, 122–5, 248
Pin point, 234–6, 246
Pitching on the launch, 78–79
Pitching, 15–16, 61
Pitot head, 6, 187–9
Position error (P.E.), 188–9, 215, 249
P.Z.L. variometer, 191–6

Races, 253
Radio, 14, 77, 183
Rates of climb and sink, 157, 239–43
Records, 253
Retrieving, 183
Rights of way, 57
Rolling, 15
Rudder, 6, 15, 16, 18, 19, 60
Rules of the air, 57, 58, 155, 156

Sea breeze, 137, 172, 232
Sense of balance, 208–10, 216–17
Sideslip, 73, 83, 181
Signals, 4, 12, 13, 53
Signals on aerotow, 116
Signals to the winch, 76, 79, 80
Silver "C", 230, 251, 252
Sites, 2, 38–39, 49, 160
Skid, 18, 21, 22, 213
Skylark, 104, 118, 122, 245, 248, Plate 5
Slip, 18, 21, 22, 63, 68–70, 213
Slope, 174, 176
Smoking barograph charts, 204–5
Sound, 18, 210, 220
Spinning, 34–38, 61, 68, 88–94, 209, 214–15
Spiral dive, 35, 91, 92, 198, 209, 214
Square circuit, 49
Stability, 17, 66, 88, 94, 212
Stall, 32–34, 44, 64–68, 85–94, 98–100, 214
Stall turn, 127
Static vent, 187–8, 215
Steep turn, 64, 68–69, 101, 216
S turn, 42, 46–47, 55, 158, 177

Take off, 7, 23–27, 52, 77, 109, 116, 117
Thermal, 130–52
Thermal soaring, 139–52, 158, 159 240, 241
Total energy variometer (T.E.), 143, 146, 192–95

Towing aircraft, 107–8, 111
Trailer, 183
Trimmer, 6, 110, 123, 212
True airspeed (T.A.S.), 188–9
Turbulence, 28, 34, 100–1, 126, 143, 145, 210, 215–19
Turns, 18–22, 60–72, 101, 114–15
Turn and slip indicator, 6, 22, 196–8
T21b, 17, 21, 104, Plate 2
T42 Eagle, Plates 1 and 2

Variation, 199–200, 233
Variometer, 6, 144, 191–96, 244
Venturi, 6, 194–6
Vital actions, 23

Washout, 87
Wave, 161, 165–9
Weak link, 11
Winch, see launch
Wind direction, 81, 172–3
Wind gradient, 28, 34, 41, 97, 101, 103, 173
Wind shadow, 135–6

Yawing, 15, 16, 60–61, 65–68